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**Journal Contact:** Meri Raggi, via Belle Arti 41, Dept. of Statistics, 40124 Bologna; Email: meri.raggi@unibo.it

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Editorial

# Farmers' motivations and behaviour regarding the adoption of more sustainable agricultural practices and activities

Linda Arata[1], Davide Menozzi[2]

[1] *Università Cattolica del Sacro Cuore, Department of Agricultural and Food Economics.*
[2] *University of Parma, Department of Food and Drug.*

The IX EAAE PhD workshop took place on June 22-24, 2022, in Parma (Italy). A number of 126 PhD students from 72 European and non-European universities gathered together to attend keynote speeches, present their research and get feedback on that, informally talk and share research experiences and opinions, enjoy free time events. Talking with some of these students afterwards, you could realise how well-organised, fruitful and inspiring the three-day workshop was. For most of them, it was the first opportunity to present their work, share research challenges, and receive feedback from peers and senior economists in a conference setting. Once the PhD workshop was over, the participants were invited to submit their presented papers to *BAE Bio-based and Applied Economics*. The received original manuscripts underwent a double-blind peer-review process and five of them are finally part of this Special Issue. All of these five studies use primary data and analyse farmers behaviour. Four of them are focused on African countries. The studies report interesting insights into the analysis of farmers' aspirations (Deißler et al., 2023), of the factors affecting the adoption of strategies for adapting to climate change (Onyenekwe et al., 2023), of diversifying in off-farm activities (Ceriani et al., 2023), of improving economic, social and environmental sustainability with livelihood strategies (Prazeres, 2023) and agroforestry practices (Seegers et al., 2023).

The paper of Ceriani et al. (2023) entitled "How do farmers' pluriactivity project evolve?" investigates the motivations that lead farmers to diversify their income through off-farm activities, the barriers to diversification, and the management strategies for a long-lasting choice. The data were collected in Northern France through farmers interviews, and the results show that the balance between agricultural and off-farm activities changes over time depending on family context, job opportunities and financial situation. The maintenance over time of the off-farm job is favoured by the flexibility of both on-farm and off-farm activities to adjust to each other and by the possibility of hiring labour on the farm.

The paper "Heterogeneity of adaptation strategies to climate shocks: Evidence from the Niger Delta region of Nigeria" authored by Onyenekwe et al. (2023) analyses the adaptation strategies to climate shocks uptaken by farmers and fishermen in the Niger delta region (Nigeria) and the main factors driving their adoption. The econometric analysis of the data collected from more than 500 interviewed farmers and fishermen shows that livelihood diversification, crop management, soil and water management strategies are the solutions mostly adopted. Fishermen use mainly livelihood diversification as an adaptation option. The study finds that household size and education are the main determinants of adoption, independent of the practices being adopted, while the factors discouraging the adoption are practice-specific.

The study by Prazeres (2023) entitled "Organic cocoa farmer's strategies and sustainability" investigates the social, economic and agro-ecological factors affecting the choice of livelihood strategies by organic cocoa producers in São Tomé and Príncipe. The study collected data through a survey administered to 810 farmers belonging to organic cocoa cooperatives and finds that education level, perception of social class, insurances, loans and access to services are the main determinants of livelihood strategies.

The paper authored by Deißler et al. (2023) entitled "A complex web of interactions: Personality traits and aspirations in the context of smallholder agriculture"

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assesses whether personality traits contribute to shaping the individual aspirations of smallholder farmers, and how aspirations are connected with their socio-demographic characteristics. The statistical analysis of data collected from 272 smallholder farming households in Kenya, shows that openness, conscientiousness and extraversion affect aspirations, which are additionally influenced by extrinsic factors. The study concludes that analysing aspirations when evaluating development projects and policy is important for an effective outcome of the intervention.

In their work "Exploring the effectiveness of serious games in strengthening smallholders' motivation to plant different trees on farms: Evidence from rural Rwanda" Seegers et al. (2023) use a role-play game to raise farmers' awareness towards agroforestry adoption. The study involves 72 small-scale farmers from Rwanda and interviews them before and after the game. Results show the effectiveness of the game to increase the knowledge of the benefits of planting different tree species on the farm as well as the motivation to take that action.

Overall, the studies included in the Special Issue provide new insights into farmers' behaviour analysis, in particular from developing countries. The authors emphasised relevant insights for policy-makers and researchers on the factors able to affect the adoption of strategies for improving the economic, social and environmental sustainability of farming activities.

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**ORCID**
CC: 0009-0003-3733-6536
AD: 0009-0003-3026-6467
MC: 0009-0009-9871-8021

# How do farmers' pluriactivity projects evolve?

Clarisse Ceriani*, Amar Djouak, Marine Chaillard

*GRECAT, ISA - Junia, Lille, France*
*Corresponding author. E-mail: clarisse.ceriani@junia.com

**Abstract.** Long criticized, pluriactivity is now perceived as an alternative agricultural strategy and it is becoming a subject of support policies. However, having an off-farm job generates organizational issues that can penalize the viability of this strategy. In this paper, we study the initial motivations of pluriactivity and the strategies developed by farmers over time to handle pluriactivity difficulties and we examine conditions that lead to permanent pluriactivity or not. We use an original qualitative approach interviewing 29 pluriactive farmers in "Nord-Pas de Calais", region located in northern France. Our results show that pluriactivity is a dynamic strategy and farmers develop different strategies to adapt their pluriactivity over time to their farm requirements and time constraints. We find that most of the trajectories lead to a permanent pluriactive status, but pluriactivity lasts longer when both activities adapt to each other.

**Keywords:** pluriactivity duration, agriculture, pluriactivity projects, farm management strategies.
**JEL codes:** Q10, Q12, L29.

## 1. INTRODUCTION

The agricultural sector has experienced several crises in recent years that challenge the conventional production model and encourage farmers to develop income diversification strategies. There is a wide variety of on-farm income diversification that are effective in improving the profitability of the farm such as agricultural output diversification and non-agricultural income diversification (Salvioni and *al.*, 2013). The diversification path can also take the direction of an off-farm job. Following this strategy, farmers decide to allocate part of their labour forces to off-farm professional activities. Farmer's pluriactivity is an old agricultural strategy but little appreciated by the agricultural world and by the research community which, for a long time, thought that working outside the farm was a marginal strategy. Nevertheless, farmers' pluriactivity presents a set of advantages at the territorial and individual levels. In some respects, this strategy responds to the new requirements of multifunctionality of agriculture, including land use and social networking. Often synonymous with part-time salaried employment, pluriactivity can support local development by favouring the reception of new urban populations with specific needs (sport, cultural activities …) and thus meet the new objectives of the agricultural policies that aim to boost rural areas by creating jobs (Blanchemanche *et al.*, 2000). Some ter-

ritories have integrated the economic and social cohesion benefits of pluriactivity and set up new policies to support this strategy (Tallon and Tonneau, 2012). For farmers, pluriactivity has many different motivations (Mage, 1976) but at first, it can compensate for low farm incomes, for their variability, and it can even play a structural role by facilitating investments on the farm (Glauden *et al*., 2006, Butault *et al*. 1999). It can therefore provide an interesting economic answer to new farmers who are more sensitive to "comfort of life" and for whom farm income volatility is an impediment to installation (Simon, 2013). On the other hand, having an off-farm job and combining two activities can be hard to handle over time and generates organizational constraints, in particular increasing worktime (Keating, 1987) that raises questions about the viability of the project. However, most of the time pluriactivity becomes a permanent path (Corsi and Salviani , 2017; Barlett, 1986) even when it was intended to be transitory and in support of a gradual farm installation (Ceriani and Djouak, 2018)

The agricultural projects of pluriactive farmers are multidimensional and dynamic. They combine both professional projects and family/personal life and must evolve according to the economic and territorial context but also depending on opportunities and organizational constraints (Dedieu *et al*., 1999). Initial pluriactivity projects can be short-term, linked to farms' financial difficulties, or longer-term, due to a desire to conduct several activities. However, initial conditions (socio-economic, organizational, motivation, etc.) can evolve and make pluriactivity permanent or not. The following questions therefore arise: Does the duration of pluriactivity depend on the initial project? How do farmers adapt and organize their pluriactivity over time?

In this work, we are interested in pluriactive farmers' trajectories. More specifically, we study the initial motivations of pluriactivity and the management strategies developed by farmers over time to reconstitute the paths that lead to permanent pluriactivity. We use an original qualitative survey with 29 semi-structured interviews of pluriactive farmers in *Nord-Pas de Calais* (NPdC) in France that explores farmers' life trajectories and expectations about pluriactivity. After presenting our methodology to collect and analyze the farmers' narratives, we present our results concerning initial pluriactive projects, farm management strategy and duration of pluriactivity. These elements are then cross-compared to reconstitute trajectories and understand better how farmers adapt their organization and expectations to handle their pluriactivity. Finally, we discuss our results and conclude.

## 2. METHODS

### *2.1. Theoretical typology of the initial project*

Pluriactivity can be considered at different scales; at household level (the household is said to be pluriactive if at least one individual has an off-farm job), or at the farmer level (farmer has an off-farm professional activity). We study farmers' pluriactivity because we want to focus on pluriactivity as a (new) professional strategy and a farmer is considered pluriactive if he or she has a job outside the farm[1].

In this paper, we are interested in the organizational strategies developed by pluriactive farmers. Many studies have worked on the duration of the agricultural pluriactivity and found that most of the time pluriactivity is a permanent path (Barlett, 1986), but they do not compare that long-run situation with the initial expectations of the individual. Using a panel of Italian family farms, Corsi and Salviani (2017) have found strong evidence that the off-farm duration is due to farmers' unobservable characteristics (i.e. risk aversion, preferences…) and to state dependence (e.g. changing status may imply sunk cost because pluriactivity requires time to find a job, to set up the organisation of the farm, allocate the production factors…). Recently Ceriani and Djouak (2018) have studied more than 60 pluriactive farmers' interviews and found that most of them wanted to be only a farmer when they set up, but the farm was not profitable enough. Therefore, for some farmers, pluriactivity was intended to be transitory and in support of a gradual installation but socio-economic constraints or job opportunities have impacted their motivations and expectations. Some previous studies also noticed that the "intent" of the operator is an important factor that should be used to discriminate the duration of pluriactivity (Boudy, 2009; Mage, 1976). Indeed, initial pluriactivity motivations are important in pluriactive systems (Tallon and Tonneau, 2012) and impact the way farmers value their production (income, social ties, environmental criteria…). To analyze the dynamic process of pluriactivity and identify the different strategies farmers can develop and use to adapt their pluriactivity in the long run, we first need to differentiate the initial motivations and expectations of part-time farming.

[1] This definition does not include activities of diversification which, being an extension of agricultural activity, does not open up to another status. Moreover, diversification is another agricultural strategy that requires different farmers' skills and generates other organizational constraints that represent a barrier to the adoption for many farms (Bartolini and *al*., 2014). For the same reason, the household's pluriactivity (companion exercising a profession outside the farm) is not included and analyzed in this article.

**Table 1.** Initial pluriactivity projects.

| Initial pluriactivity project | |
|---|---|
| | Set up: Farmers already have a job when they set up. They keep the off-farm job to support investments in the farm (new lands, new productions for example) and increase farm income. Pluriactivity motivation is essentially economic, and pluriactivity is *intended to be transitory* because *farmers want to be 100% on the farm* in the long term (what Mage (1976) calls the "aspiring type"). |
| | Survival**:** This situation is a necessity; the *farm is the main activity* and farmers must take another job due to *farm or personal occasional financial issues*. Those farmers did not want to be pluriactive, but it is the only way to continue being a farmer and save the farm ("transitional part-time farmers" for Barlett (1986)). |
| | Passion: The main motivation is passion for agriculture and farm activities. Farmers set up in agriculture to live their dream and keep the family farm. Farmers already have a full-time job that is important, for income but also for open-mindedness. *Farmers would have been 100% on the farm when they set up, but farm incomes were not sufficient*. One day they might leave the off-farm job to be full-time farmers ("Hobby farmers" for Mage (1976)) |
| | Patrimonial: Farmers already have a *full-time job outside the farm*, they want to keep it because it is important to them economically but also socially, so they have *no intention to leave it*. The main motivation for pluriactivity is the maintenance of the family heritage. *Pluriactivity is supposed to last*. ("Investors" for Barlett (1986)). |

Four initial pluriactivity projects depending on farmers' motivations and professional situation at the time they set up in agriculture can be defined. Like Barlett (1986) and Mage (1976) before, we consider short run projects when farmers use the off-farm job to invest in the farm to expand it or to save it when it has financial issues. On the other hand, some pluriactive projects are intended to last longer either for strong patrimonial motivations or because farmers are passionate about farming, but do not want to become full-time farmers. Table 1 displays more details about this typology of initial pluriactivity projects.

### *2.2. Farm management strategies*

Regardless of the initial motivations and projects of pluriactivity, combining two activities generates various constraints and in particular increases the working time. It implies time constraints and organizational issues. There could be an additional workload even when the other job is a source of well-being and personal fulfillment. According to Wilkening (1981), the same number of hours spent in an off-farm job will be more stressful for farmers since it will represent "wasted hours" for their real job as a farmer. The same observation is made by Keating (1987) who highlights a feeling of competition between off-farm employment and agricultural activity. These difficulties are variable, directly related to the farm characteristics and the type of off-farm jobs but they can be a source of stress and dissatisfaction (Mc Coy and Filson, 1996, Keating, 1987). Mc Coy and Filson (1996) highlight the fact that pluriactivity also impacts the quality of time spent by pluriactive farmers with their families but also limits their own free time.

To reduce these constraints and effectively manage their pluriactivity, farmers have to develop strategies according to the farm's requirement and their motivations. Indeed, some farmers will develop strategies to maintain the pluriactivity and to make it more comfortable and others will try to leave this situation. We assume that farmers' strategies can be analyzed regarding two factors: (i) Farm investments and prospects; (ii) Socio-economic and organizational constraints. We pay attention to farm projects (the will to develop new production or to find new lands…) and to farmers' intentions about the pluriactivity (the wish to stay pluriactive or to change in the future). For the organization of pluriactivity, we analyze time constraints related to the off-farm job such as flexibility because agricultural activities must deal with exceptional constraints such as bad weather and livestock surveillance that might affect the organization (Dedieu *et al.,* 1999). We also consider the available labour resources (employees, volunteers…) because the labour force is a decisive resource in the management of the farm and it impacts its organization (Fiorelli *et al*., 2007; Laurent *et al.,* 1994).

### *2.3. Pluriactive Farmers' trajectories*

In the last part, we examine the various elements to set up trajectories that lead to a permanent path or not. More specifically, to better understand the conditions that lead to a permanent pluriactivity, we combine the initial project, the strategy on the farm and the "chronological" dimension of pluriactivity (its previous duration on the farm and the future projections of its future existence on the farm).

### *2.4. Data collection and analyses*

The study was conducted in the *Nord-Pas de Calais* (NPdC), a part of a French region (called *Hauts de France* since 2014) located in the north, bordering Bel-

gium. Agriculture is an important sector that occupies two-thirds of the territory: in 2010, the Utilized Agricultural Area (UAA) represented more than 66% of the total area of the region. Agriculture remains highly diversified: field crops, livestock (Avesnois and Boulonnais dairy), and horticulture (in suburban spaces) (Agreste, 2015). Pluriactivity is an old phenomenon that tends to increase, but so far, there is still a lack of empirical data and studies on pluriactive farmers in the NPdC.

To better understand farmers' paths in a dynamic perspective from their initial project to their current strategy, the richness of a qualitative approach using open questions is required. Such research requires at first a deep understanding of farmers' initial motivations, the reasons for which farmers got an off-farm job, the set-up conditions, the family farm history, and their professional career. To achieve this, we decided to conduct a pilot study selecting 29 pluriactive farmers with a wide variety of personal and professional situations. Indeed, an increasingly marked redundancy of collected narratives was observed when we reached this amount, which can be interpreted as the effect of a form of a data saturation relating to the various situations encountered. A summary description of these narratives is detailed in Table 1 in the appendix. Interviews started with some questions concerning farmers (age when setting up in agriculture, education level, family situation, etc…) and farms (UAA, legal status, production …). Then, we asked farmers to tell us about their installation in agriculture and their personal/professional trajectories. Next, we asked the farmers to detail their pluriactivity, initial and current motivations, advantages and disadvantages of this double life, and their expectations for the future. At the end of the interview, some questions related to the financial situation of the farm and the workforce were included.

A thematic approach was used to analyze the collected qualitative data. This approach enables us to go beyond simply counting words or phrases in the text and to explore explicit and implicit meanings in the data. Indeed, with the thematic analysis, we used "themes" (and "sub-themes" to refer to the breakdown of certain themes) to summarize and process the collected material. In short, it is a question of breaking down, recomposing, and associating the main ideas contained in our material, to respond little by little to our main questions: What is fundamental in the farmers interviews to help us see things more clearly? In addition, an empirical-inductive approach was adopted (which is used when there is not much information available related to the problem studied), this is justified by the highly exploratory nature of our investigation, as well as by our need to identify the parameters of aspects relating to the farm management strategies which are truly specific to pluriactivity in agriculture. Finally, this general process allowed us to categorize farmers according to their initial pluriactivity project and to identify different farm management strategies developed by farmers. Thus, dynamic trajectories could be constructed, which made it possible to make the link between the initial project, the strategy on the farm and the "chronological" dimension of pluriactivity.

## 3. RESULTS

### *3.1. Initial motivations and projects of pluriactivity*

Pluriactivity motivations and expectations depend on family context and job opportunities. The reasons why farmers decided to become pluriactive at first allow individuals to be classified according to four types of initial projects and motivations (Table 1, "initial project" line).

Like Barlett (1986), we found that a major motivation is economic, but in different ways. Among the 29 farmers, 8 wanted to use pluriactivity as a transitory development project to develop the farm and make it more profitable (set up type). We observed that 7 farmers took an off-farm job because their farm incomes were not enough and so for them being pluriactive was a necessity, a forced choice to compensate for temporary financial difficulties (survival type).

Passion is very important as well: 8 farmers had a passion for agriculture; they wanted to become a farmer, at least a part-time one and they all grew up in an agricultural environment. According to them, the financial situation of their farm was not bad, but the farm was not big enough to leave the off-farm job and become only a farmer. Moreover, the other job was important for them, economically and socially, that is why they decided to combine two activities. Pluriactivity was a positive choice when they set up: "Yes, it was a desire to be pluriactive, in fact, I did not see myself a full-time farmer… I had a real love and interest in farming, but at the same time I had the desire to have another job activity, physically to be on the move, to be able to travel a little bit… so, farming seemed a little too sedentary to me actually "(passion type).

Almost all the farmers we interviewed took over the family farm, which implies patrimonial motivations even if the weight of those patrimonial motivations differs among farmers. Indeed, we found that 6 farmers had a patrimonial project at first, and even if most of them wanted to become a farmer and work on the family farm, they never intended to be 100% on the farm. They consider agriculture as a secondary or complemen-

tary activity while the off-farm job plays an important role, financially but also for personal identity:" (speaking of agriculture) it is secondary because my off- farm job is really important in my professional life" (individual A7). For these farmers, pluriactivity has imposed itself as the only way to preserve the family farm, perpetuate a family tradition, a commitment undertaken a long time ago by parents, grandparents, etc…but also the only option to enable them to pursue their passion for agriculture. "It is only a family project […] it is the result of the work of generations before us, but it is true that if there had not been children behind, we did not necessarily make it… we would not necessarily have taken the step." (individual A7) (patrimonial type).

Eventually, when we asked the farmers if they wanted to be pluriactive when they set up on a farm, a majority (21 farmers) clearly said that they would have been 100% on the farm when they set up in agriculture, if the farm revenues had been sufficient. Thus, 72% of the pluriactive farmers we interviewed did not want to be (or stay) pluriactive at first. Even if some of those farmers did not try to develop the farm to make it more profitable, this result is important because it means that for many pluriactive farmers, pluriactivity was neither the ideal nor the first choice.

### *3.2. Dynamic farm management strategies*

The analysis of the organization of pluriactivity included work on the farm, advantages and disadvantages of pluriactivity felt by the farmer, as well as farm investments and projects. We identified 4 different strategies that farmers use to face organizational issues and reach their expectations (see Figure 1 "strategy" line).

*Development strategy:* Some farmers are in a proactive strategy, using pluriactivity to develop farm revenues so as to be able to live on farm incomes only and leave the other job soon. Farming is the most important activity. For the moment, farm incomes are not sufficient, and part of the other job income is used to invest in the farm. Some of them had a set up motivation and are young farmers (installed for a few years). Most of them have livestock farms. Sometimes, developing the farm means expanding or creating a new activity on the farm: "Being pluriactive has reinforced the development of my Angus direct sales workshop for sucklers… As long as I have not reached a sufficient number of cows, I will remain pluriactive"(individual A25). Another way to increase farm income can be the transformation of the family farm and its organization; as individual A24 says that this situation permits him to take some risks without pressure: "Anyway, we are much more confident in what we do. […] I knew I wanted to do organic vegetables, but I had no idea how to do it, I even complicated things by working with the old varieties of wheat, by working in a local distribution network, etc. …Concerning the other profession, it allows me to take more risks in my agricultural activity if necessary". Farmers who belong to this type of strategy are quite satisfied with their pluriactivity because it allows them to set up in agriculture in better conditions, with less risk because the financial security of the other job gives them the opportunity to develop the farm. However, they can be frustrated by not being fully dedicated to the farm, in particular in case of livestock farming: "When you are at the town hall and have a lot of work on the farm, it is annoying because you are not at the right place " (individual A6).

*Farm disengagement strategy:* The farms' financial situation was quite bad, so farmers took another job to save the farm. The farm had not been organized at first for a pluriactivity because the farm was the only activity of the farmer. Due to financial issues, farmers quickly took full-time off-farm jobs that most of the time were not flexible. A majority are livestock farming which requires intense demand for labour and does not fit easily with pluriactive time constraints, in such a way that farmers have to reduce farm activities. In this category, two subtypes of farmers can be differentiated:

– The happy one who wants to keep being pluriactive. Those farmers seem to be satisfied with their pluriactivity because they decided/accepted to reduce and simplify farm activities as much as possible. Those farmers have less stress, more time such as individual A19 who eventually found his job balance: "The strong points are the simplicity of my work and a lot of free time. I spend very little time on my holding. I don't want to develop things anymore, I'm too close to retirement". The other job enables them to increase revenue and reduce risk, and they also find that it enables social contacts and open-mindedness.
– Unsatisfied farmers who think about leaving agriculture. These farmers do not invest anymore in the farm, but the farm organization remains incompatible with pluriactivity. They highlight tight schedules and working weeks that sometimes exceed 60 hours which leaves little time for leisure and family. There is frustration because the off-farm job appears in competition with their farm activity (Keating, 1987). For some farmers, time spent outside the farm may even be perceived as a lost time for the "real" job of farming (Wilkening, 1981). Agricultural politics clearly impact these farmers and increase their dissatisfaction "We are not compensated for the work

we provide… still low milk price and the rise of financial charges!" (individual A12).

*Responsive strategy:* Some farmers adapt the farm to their off-farm job as they want to be pluriactive. They keep on investing in the farm and keep on developing farm projects, but they want to have another activity outside the farm. For most of them, the other job is qualified, and they like it. They are convinced that their agricultural activity improves their off-farm work efficiency. Indeed, it provides entrepreneurial and business skills; it enhances professional networks and gives them a better legitimacy in their work: "(about the farming activity) As part of my job, it brings me a lot of things, both professionally, also socially, somewhere, because I am in contact with other farmers, social networks that are different. I have contacts with my fellow farmers as part of my CUMA[2], with the new owners. There are many circles of exchange that are, in my opinion, positive, that I would not have if I were only an employee of the Chamber of Agriculture" (Individual A27). Some of them have changed farm organisation or production to reduce time constraints, such as individual A4 who oriented the agricultural activity towards automated production which requires less labour and when necessary, gets occasional supports and help from family or friends. Others have an agricultural enterprise that requires significant workload and presence on the farm but the off-farm job is flexible so they can free up time when needed such as individual A5, a cattle farmer. This strategy involves reciprocal adaptation of both activities. However, pluriactivity can be constraining and even frustrating: "What is difficult for me is to accept to be locked up when the weather is nice, or to accept when an animal is not fine or maybe I'll find it dead at night […] it is difficult to handle the fact that if I would be there, I would manage to cure it or I would be at home I would be able to cut wheat because it is ready" (individual A3). These farmers have a positive image of farm work: farmers have their own business, which gives them independence and a freedom to make decisions. Farmers have multiple functions and diverse skills: "I am a farmer, a business leader who takes into account different dimensions: technical dimension, economic dimension and then environmental dimension" (individual A20). They think that pluriactivity gives them the possibility to be in « both worlds », it opens their mind. Most of those farmers seem to be confident in the future and in their capacities, and most of them are in a proactive entrepreneurial logic: they maintain the family heritage, remain open to possible evolution of their farm and their career without being limited to technical conceptions, or cultural and legal aspects of the profession (Lagarde, 2006). "On the heritage side, I am very proud of myself. I have two activities and maintained this farm that may be passed down to my children. I am also very proud to maintain an agricultural business…" (individual A27). Still, even when pluriactivity seems to be pleasant, many farmers note work overloads and time constraints: "The disadvantages (of pluriactivity) are double organization, double stress. We combine two different professions and therefore two different stresses. We also have different deadlines." (individual A26).

*Managerial strategy:* Other farmers have developed a managerial strategy and have regular employees who manage a large part of the farm work, almost independently. These pluriactive farmers do not consider the farm as their most important activity and most of them became pluriactive for patrimonial motivations. This type of organization of the farm makes the farmer appear as "a manager" who delegates a part of the work to one (or more) trusted person, family members or employees. An essential element of this "managerial" organization of pluriactivity seems to be having someone present on the farm daily. This can be an employee: "Today it is the employee who does all the work … for the anecdote?? I address him with the courtesy "*vous*" because he is my employee, but he knows me from my childhood… I do not need to see him every day, there is trust and he agrees to be autonomous" (individual A1). It can also be a family member who keeps an eye on the farm. The ability to adjust the off-farm work schedule to free up time thanks to its flexibility and the choice of an agricultural enterprise (no livestock farming or vegetables) with fewer time constraints reduce the stress and constraints: "I can easily arrange things with my employee. I make myself available in winter for stand-by duties that I compensate for in the summer at the time of the harvest. So, there are no worries… my tractors return in October to the buildings and come out in February to spread fertilizers. I have six months to disconnect the batteries" (individual A8). This "managerial" governance combined with an optimal organization of the time spent on the farm allows them to consider the future of their pluriactivity with greater serenity.

### *3.3. Reconstitution of individual trajectories*

Having analyzed various elements of the pluriactivity: initial project and strategy; we can now set up trajectories and analyze the link between these different ele-

[2] *Coopérative d'Utilisation de Matériel Agricole*, Cooperative for the use of agricultural equipment

**Table 2.** Summary of farm management strategies.

| | |
|---|---|
| Strategies | Development strategy: Farmers work on the farm regularly and farm activities tend to be more important for farmers. *Farmers work to develop farm activities; they continue to invest in the farm and farm revenues tend to increase*. The off-farm job is secondary, and the farm has not been arranged or adapted to the off-farm job. Pluriactivity is not well organized and tends to be tough for farmers. |
| | Farm disengagement strategy: Farmers work on the farm regularly without help. The off-farm job is not flexible, but they cannot employ someone because the farm has *financial problems. Farmers cannot develop the farm*; they do not invest anymore in the farm and *farm activities tend to become less important* for farmers. They keep the off-farm job because it is the only way to maintain the farm and it provides them a constant revenue. |
| | Responsive strategy: Farmers work on the farm regularly thanks to organized pluriactivity which avoids time constraints and organizational issues. Either the *off-farm job is compatible* with the farm work obligations or a *salaried labour force* is mobilized when needed. *Farmers still develop and invest in the farm*. Moreover, pluriactivity is meaningful, and has social and economic advantages for the farmers. |
| | Managerial strategy: Pluriactivity is *well organized* and most of the *farm work is done by employees*. Pluriactive farmers do not feel pluriactivity is restrictive since they do not have to be on the farm every day. Farm revenues are sufficient to at least pay bills. |

ments to identify the conditions that lead to permanent pluriactivity (Figure 1). We will not detail all the possible trajectories but the most important and frequent ones that apply to 19 farmers.

*Development strategy:* Some of them had a set up motivation and are young farmers (installed for a few years). Others had more survival motivations and succeeded to switch into a development strategy. Those farmers do not want to stay pluriactive and think about leaving the off-farm activity as soon as the farm revenue is sufficient "As long as I have not reached a sufficient number of cows, I will remain pluriactive"(individual A25).

*Farm disengagement strategy:* Due to financial issues or setting up in agriculture, farmers took an off-farm job. Diverse constraints forced them to adopt a disengagement strategy towardsthe farm. Some are unsatisfied with this situation and might leave agriculture one day because the farm's financial situation is bad, and they feel they do not belong to the "agriculture world" anymore. Other are satisfied and they see their situation as permanently or transitory disengagement, depending mostly on their age.

*Responsive strategy:* Farmers motivated by a passion to farm, pursuing a responsive strategy. Some of the "set up" type found good compatibility between both activities and developed this strategy, too. A majority of these farmers consider their pluriactivity as a long-term strategy. Indeed, some of these farmers do not really want to

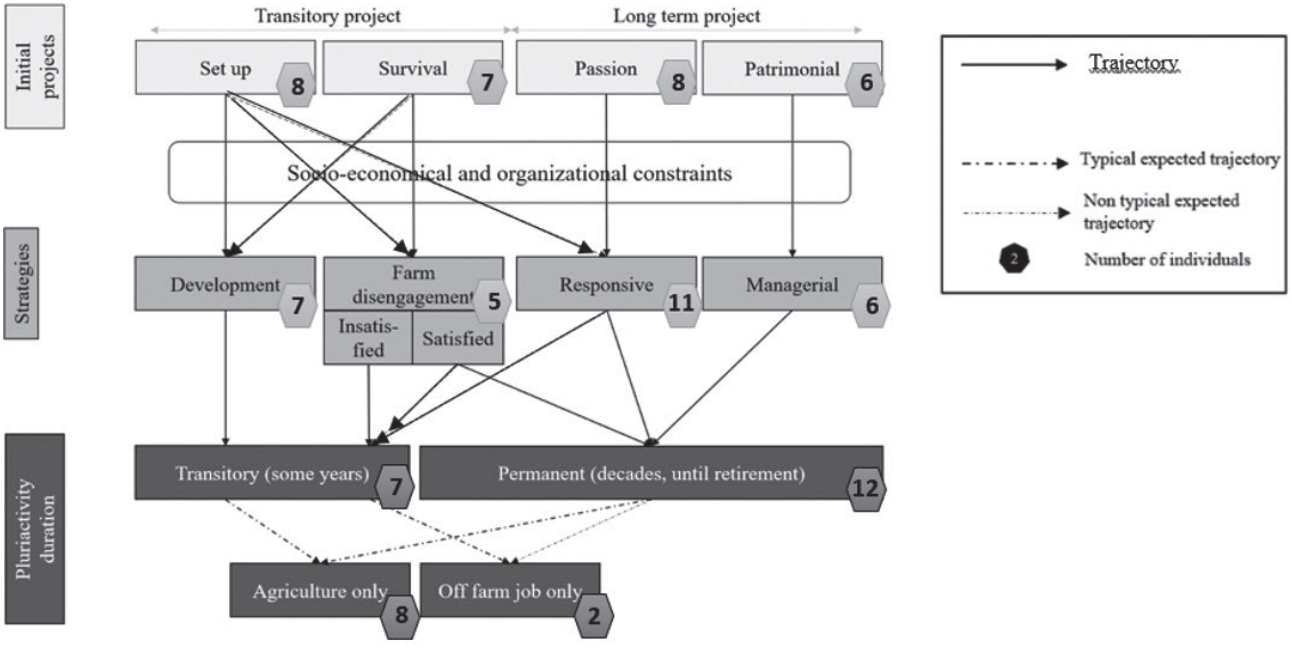


**Figure 1.** Dynamic typology of the pluriactivity strategies.

stop pluriactivity in the short term, but they still consider pluriactivity as a transition. They seem to be willing to leave their off-farm job one day to become "*just a farmer*" because they think the work overload will be too much. "I like it. Satisfied, yes. After that, I'm not saying it's easy every day. Some days when you have to run, you run. That's why I put it into perspective. Today, I'm young, it's okay. Maybe ten years from now, I will not be willing to run like this anymore. There is, I think, an evolution over time, with age, which will change priorities. Pluriactivity works great for a while, but not forever. I don't see myself pluriactive until I am 65." (individual A22).

*Managerial strategy:* Due to cultural motivations, these farmers all want to stay pluriactive and they are proud of keeping the family farm, despite their other job: "I managed to set up a system that allows me to get my own farm, to manage the farm without limitations, so I am very happy with what I did" (individual A9). They want to manage the farm until its transfer to their children.

## 4. DISCUSSION

*Stable long-term projects:* These long-term projects include passion and heritage projects. Starting a pluriactive approach with these types of motivations induces specific strategies: responsive in the first case, and managerial in the second. Indeed, the necessary conditions to take over the farm were thought out within a framework of managing the farm while being pluriactive, but a certain financial stability was required. Moreover, pluriactivity has been conceived and organized from the beginning so that time constraints and work overload are reduced, which facilitates the articulation of the different activities. In the first case, the farm is the place of fulfilment and experimentation, and farmers spend a large part of their time on the farm, whereas in the second case (with more cultural/heritage motivations) farmers manage the farm in a more distant way. Time has not changed the initial motivations and projects and farmers are satisfied with their pluriactivity, which brings them a strong complementarity between their two activities. Pluriactivity is therefore considered for the long term, for several decades, or until retirement.

*More flexible transitional projects:* Initial "set up" and "survival" projects imply strong motivation for agricultural work and a transitional pluriactivity attitude. Indeed, we observe that farmers with "setting up" initial motivations and farmers with "survival" initial motivations tend to be following a farm development strategy and a farm disengagement strategy, respectively (in particular, among farmers who do not manage to recover the financial balance of the farm or to set up properly). However, strategies can evolve and so trajectories can be more complex. For instance, we found that some farmers who have reduced their farm engagement (disengagement strategy) have more experience (the majority have been farming for more than 16 years) and tried to develop the farm first (development strategy).

However, we also observe that some pluriactive farmers who were in the process of setting up their own businesses have found a certain complementarity and balance between the two activities that allow them to develop a more responsive strategy. In particular, farmers who develop their farm are more likely to continue pluriactivity as long as it brings them advantages, they are in a transitional but dynamic pluriactivity with the aim of leaving the off-farm job someday. On the other hand, when investment in the farm has not been possible, pluriactive farmers are forced to reduce their agricultural activities to handle both activities together. This situation can be experienced as unsatisfactory even if pluriactivity is considered as an opportunity to keep the farm.

Initial transitional projects enable transitional pluriactivity that allows farmers to develop and (re)invest in the farm to improve the future farming conditions. When the financial and organizational situation do not allow for saving the farm, pluriactivity can be experienced as a failure and farmers can cease agriculture. This type of initial project can also lead to unexpected long-term trajectories, with differentiated investment in the farm, but both activities create a form of complementarity for the pluriactive person.

## 5. CONCLUSIONS

Our research is based on a qualitative approach that allows a deep understanding of farmers' motivations and trajectories. Our results confirm that pluriactivity organisations and expectations tend to change over time depending on the family context, job opportunities and financial situation of the farm; and the way farmers adapt their pluriactivity is usually related to their initial project. However, some unusual trajectories show that farmers' strategies evolve according to the context and this can also modify motivations and expectations. Indeed, finances, organizational constraints and work overload are critical factors that can modify the initial pluriactivity project. It appears that work overload and incompatible schedules might change initial expectations such as individual A14 who was leaving an off-farming job at the time of the interview, even though

this job provided additional benefits to their agricultural activity and personal life.

Our results indicate that pluriactivity is easier for farmers and lasts longer when both activities adapt to each other, for example when the off-farm job requires lots of time, farm production must be less demanding in terms of the workload. Also, the possibility of hiring regular or permanent labour makes it easier for farmers. Indeed, the presence of a complementary source of labour appears highly significant in terms of the durability of pluriactivity because it allows farmers to be less present on the farm, and it limits not only the workload but also the "competition" between jobs that can generate stress (Keating, 1987). The "partial" presence of the farmer on the farm compensated by non-family labour raises the question of the identity of the pluriactive farmer, their managerial skills, and the farmer's position as executive director (Legagneux and Olivier-Salvagnac, 2017). Most of the farmers we interviewed consider themselves farmers-entrepreneurs because their vision of the job is different from that of their parents and grandparents. This new perspective of being a farmer can be related to an increase of the use of salaried workers on farms since the 2000s (Legagneux and Olivier-Salvagnac, 2017) and the restructuring of work and labour organization within the farm (Harff and Lamarche, 1998).

The possibility to hire employees depends on the financial profitability of the farm, which also appears as an important criterion for the initial project's success. Some farmer interviewees expressed the wish to get an employee on the farm, but they cannot afford it. Indeed, pluriactive farmers who employ someone on the farm are the only ones who consider that the financial situation of their holding is good. Others are often in a precarious financial situation, leading them to increase their working hours in the hope of increasing farm profitability. Unfortunately, they rarely see their efforts rewarded and they follow a negative spiral: a bad financial situation requiring them to work more that causes a lot of stress, fatigue, and psychological tension and with results, in general, far from their expectations that can even be a real obstacle for future transfer of the farm to a successor or new entrant.

To conclude, this pilot study is the first step in a long-run study about the organization, adaptation, and sustainability of farm pluriactivity. Indeed, we believe that farm pluriactivity is becoming more and more common among farmers due to market price fluctuations and agricultural crises that can discourage young farmers to take over the family farm. Therefore, pluriactivity can be an interesting strategy that contributes to reduce the income variability and allows the combination of different activities and environments. This strategy however raises specific questions and issues. A deeper reflection on the support of pluriactive farmers requires an integration the characteristics related to their dual profession: time and work management, lack of labour force, organisational difficulties, etc… This consideration is important because it would improve pluriactive farmers' systems and make this strategy more sustainable and attractive for young farmers who want to set up.

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## APPENDIX

**Table 1.** Description of interviewed pluriactive farmers.

| Farmer | Description |
|---|---|
| A1 Female | Farmer in PLFC[3] and farm management advisor, field crop farm of 68 ha, 38 years old, installed for 12 years, married with 3 young children |
| A2 Male | Farmer in PLFC and sales executive, field crop farm of 62 ha, 37 years old, installed for 5 years, married with 2 young children |
| A3 Male | Individual farmer and mechanical workshop manager, crop-livestock farm of 41 ha, 40 years old, installed for 5 years, married without children |
| A4 Male | Individual farmer and employee in a battery factory, field crop farm of 42 ha, 52 years old, installed for 18 years, married with 2 children over 20. |
| A5 Male | Individual farmer and trader in cattle cooperative, cattle breeding on 35 ha, 36 years old, installed for 8 years, married with 2 young children |
| A6 Male | Individual farmer and gardens-parks manager, crop-livestock farm of 20 ha, 45 years old, installed for 15 years, single, 3 children from 5 to 18 years old. |
| A7 Female | Individual farmer and an agricultural advisor, field crop farm of 80 ha, 40 years old, installed for 1 year, married with 2 children of 12 and 18 years old. |
| A8 Male | Individual farmer and hospital employee, field crop farm of 24 ha, 48 years old, installed for 17 years, married with 2 children of 13 and 16 years old. |
| A9 Male | Individual farmer and agricultural union director, field crop farm of 57 ha, 41 years old, installed for 14 years, married with 2 children of 13 and 16 years old. |
| A10 Female | Individual farmer and specialized educator, horse breeding on 10 ha, 34 years old, installed for 6 years, married with 1 children of 5 years old. |
| A11 Male | Individual farmer and manager of a transport company, field crop farm of 50 ha, 52 years old, installed for 22 years, married with 2 children over 20 |
| A12 Male | Individual farmer and works in the construction industry, crop-livestock farm of 52 ha, 60 years old, installed for 21 years, married with 2 children over 20 |
| A13 Male | Individual farmer and machine operator, field crop farm of 31 ha, 35 years old, installed for 8 years, married with 2 children of 5 and 8 years old. |
| A14 Male | Individual farmer and employee in a battery factory, field crop farm of 42 ha, 52 years old, installed for 18 years, married with 2 children over 20. |
| A15 Male | Individual farmer and electromecanician, field crop farm of 98 ha, 35 years old, installed for 5 years, single with 2 young children |
| A16 Male | Individual farmer and gardens-parks manager, field crop farm of 25 ha, 40 years old, installed for 16 years, single, no child. |

[3] Private limited farming company

| Farmer | Description |
|---|---|
| A17 Male | Individual farmer and teacher, field crop farm of 67 ha, 54 years old, installed for 20 years, married with 3 children between 16 and 26 years old. |
| A18 Female | Individual farmer and worker in industry, cattle farming of 18 cows, farm of 10 ha, 38 years old, installed for 16 years, married with 3 children of 9 and 13 years old. |
| A19 Male | Individual farmer and worker in a medical institute, field crop farm of 36 ha, 60 years old, installed for 35 years, single with 3 children between 12 and 31 years old. |
| A20 Male | Individual farmer and CUMA manager, field crop farm of 75 ha, 34 years old, installed for 6 years, married with 2 children of 2 and 4 years old. |
| A21 Male | Individual farmer and computer scientist, field crop farm of 65 ha, 44 years old, installed for18 years, married with 2 children over 20 |
| A22 Male | Individual farmer and teacher, field crop farm of 140 ha, 36 years old, installed for 8 years, married with 2 children between 3 and 6 |
| A23 Male | Individual farmer and farmer employees, field crop farm of 57 ha, 42 years old, installed for 22 years, married with 2 children of 14 and 10 years old. |
| A24 Male | Individual farmer and office designer, field crop farm of 15 ha, 36 years old, installed for 4 years, married without children |
| A25 Male | Individual farmer and teacher, crop-livestock farm of 140 ha, 40years old, installed for 18 years, married without 5 children between 13 and 17 |
| A26 Male | Individual farmer and teacher, crop-livestock farm of 20 ha, 33 years old, installed for 13 years, single without 3 |
| A27 Male | Individual farmer and manager in Chamber of Agricultural, field crop farm of 40 ha, 45 years old, installed for 12 years, married with 2 children of 14 and 17 years old. |
| A28 Male | Individual farmer and executive manager, field crop farm of 15 ha, 48 years old, installed for 18 years, married with 3 children of 18 and 22 years old. |
| A29 Male | Individual farmer and industrial contract manager, field crop farm of 52 ha, 35 years old, installed for 2 years, married with 1 child aged 1 year |

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**ORCID**
CSO:0000-0003-2625-1775
PIO: 0000-0001-6829-6125
COU: 0000-0003-2033-0560
DBS: 0000-0001-8288-2999
ISE: 0000-0003-2067-8946

# Heterogeneity of adaptation strategies to climate shocks: Evidence from the Niger Delta region of Nigeria

Chinasa Sylvia Onyenekwe[1], Patience Ifeyinwa Opata[1], Chukwuma Otum Ume[1,*], Daniel Bruce Sarpong[2], Irene Susana Egyir[2]

[1] *Department of Agricultural Economics, Faculty of Agriculture, University of Nigeria, Nsukka, Nsukka, Enugu State, Nigeria*
[2] *Department of Agricultural Economics and Agribusiness, University of Ghana, Legon, Ghana*
*Corresponding author. E-mail: chukwuma.ume@unn.edu.ng

**Abstract.** There is overwhelming evidence to suggest that climate shocks undermine food security and livelihood well-being of the climate-impacted Niger Delta region of Nigeria. Employing survey data collected from farming and fishing households in the Niger Delta region of Nigeria, the study investigated the range of adaptation practices prevalent in the region, as well as factors influencing the adoption of these adaptation strategies. Five hundred and three (503) households (252 fishing households and 251 farming households) were selected using multi-stage sampling techniques. Multinomial logit model was used to determine factors affecting the household choice of adaptation strategies. The results show that adaptation strategies adopted by farming households were livelihood diversification (78.5%), crop management (77.7%), and soil and water management (64.5%). Factors influencing their choice of adaptation strategies were age, gender, household size, education, extension, and farm size. The adaptation strategies employed by the fishing households were livelihood diversification (83.61%) and intensification [which include the use of improved fishing gears (80.33%), varying fishing locations (67.21%), and expanding area of fishing (40.98%)]. Uncovering the heterogeneity in adaptation and resilience aspects to climate shocks has immense practical significance, particularly in providing targeted assistance for the two livelihood groups' adoption.

**Keywords:** Climate shocks, crop farmers, Fish farming, Adaptation strategies, Developing nations.
**JEL codes:** Q13, Q22, Q54.

## 1. INTRODUCTION

Crop farming and fishing constitute the main economic activity of rural people especially in Sub-Saharan Africa (Giller, 2020). It is a source of livelihood for about 70-80% of the population and accounts for 30% of the GDP and 40% of the foreign exchange earnings of most nations in Sub-Saharan Africa (Bezner Kerr et al., 2019). As climate conditions change all over the

world, there are increasingly multiple and uneven risks to societies (Arfini, 2021). In Nigeria for instance, farming and fishing constitute the main livelihood strategy for over 70% of the teaming rural population. In the Niger Delta region of Nigeria, despite the abundance of oil in the region, about 60% of the population of these rural people depend on farming for their life sustenance and livelihood (Fund World Life, 2018). Studies have also shown that the shock and impact are more on farmers in the Niger Delta region (Fund World Life, 2018; PEDI, 2020), as most of the areas in the Niger Delta region are coastal areas and as such are bedevilled with a number of environmental challenges and flood-related disasters. Also, like in most African countries, there is an over-dependence on rain-fed agriculture in the Niger Delta region of Nigeria, as well as limited adaptive capacity among the farmers (Ume, 2017). According to Akpoti et al. (2021), over-dependence on the natural environment in the face of climate change, without an adequate safety net, exposes these farmers to climate shocks, which negatively affect productivity and sustainable development. The future sustainability of the agricultural sector and food security in the region will depend on the adaptation strategies adopted by farming and fishing households (Bandara & Cai, 2014; Kahsay & Hansen, 2016). This study, therefore, seeks to investigate the range of adaptation practices prevalent in the region, as well as factors influencing the adoption of these adaptation strategies.

As developing countries have been projected to be more impacted by climate change, adaptation has been increasingly identified as the policy option to help cope with the negative impact of climate change (Ford et al., 2011; Lamonaca et al., 2021). According to the IPCC (2001), adaptation is the ability of a system to adjust in response to actual or expected climatic stimuli to reduce harm and cope with the resulting condition. The importance of mainstreaming climate change adaptation into farming activities for sustainable development is evident, and considerable research has investigated the determinants of adoption of climate change adaptation strategies among farmers in the global south, although reviews reveal mixed evidence thus far (Bezner Kerr et al., 2018; Fosu-Mensah et al., 2012; Ume et al., 2021; Zazu & Manderson, 2020). For instance, Ume et al. (2021) concluded from 14 studies in Southeast Nigeria that the gender of the farmer has a significant effect on adaptation, while Enete & Amusa (2010) found an indeterminate influence of socioeconomic factors such as age, education, and gender on adaptation. In Ghana Fosu-Mensah, Vlek, & MacCarthy (2012) found access to extension services, credit, soil fertility, and land tenure to be the major factors that influenced farmers' perception and adaptation. The authors suggested a need for more empirical investigations to establish coherence in the literature.

In contrast to the large literature on determinants of adaptation among crop farmers in the developing nations, research documenting the range of adaptation practices prevalent in the region is sparse: our literature search identified only three studies. Wetende et al., (2018) documented the different climate change adaptation strategies employed by smallholder dairy farmers in the Siaya Sub-County of Western Kenya. Sinharoy et al. (2018) assessed the determinants of crop farmers' choice of coping methods to climate change and variability in Ethiopia and usefully documented the adaptation method employed by highlands farmers. Onyeneke et al. (2018) presented the status of climate-smart agriculture in Nigeria, and categorized them into mobility and social networks, adjusting agricultural production systems, diversification on and beyond the farm, farm financial management, and knowledge management and regulations. We expand these available adaptation options in literature by documenting additional adaptation strategies and innovative agroecological farming and fishing methods that farmers in the Niger Delta region of Nigeria employ.

This paper contributes to the existing literature in three key ways. First, as highlighted above, very few studies have systematically examined the different adaptation options employed by farmers in developing nations, and these studies did not consider the peculiar vulnerabilities of riverine dwellers and fish farmers. According to the IPCC (2014), vulnerability describes a set of conditions derive from the prevailing cultural, historical, social, political, environmental, and economic contexts. For a long time, the Niger Delta region has been exposed to various degrees of environmental degradation and conflicts, hence can be referred to as a vulnerable region not only because they are exposed to climate hazards but because of everyday patterns of marginality and neglects experienced by farmers in this region.

Second, the determinants of adaptation have been extensively covered in the literature. However, empirical evidence in the context of the Niger Delta region is largely scarce. More so, the underlying drivers of adaptation are complex, and have not been fully understood (Bezner Kerr et al., 2018). Recent studies suggest that they differ from place to place according to location-specific factors (Komba & Muchapondwa, 2015; Meadows, 2008). Furthermore, there is variation in the level of influence of different determinants of adaptation, which makes it difficult to generalize findings (Ume et al.,

2020). As stated by Fosu-Mensah et al. (2012) the determinants of adaptation to climate change among smallholder farmers in the developing economies are still contentious issues, thus, making further empirical study necessary to clarify uncertainties and establish a coherent scholarship.

Finally, we are not aware of any previous study that examined the different adaptation options for fish farmers in West Africa, though the fishery sector is widely acknowledged to have the potential of improving the nutritional status of the rural population. Previous research on climate change adaptation among farmers has mostly concerned with crop farmers (Amare & Simane, 2017; Onyeneke et al., 2018; Ume et al., 2022), with a few recent studies on dairy and livestock innovations (Apata, 2011; Wetende et al., 2018). We add another empirical point to this expanding literature with evidence on adaptation options for fish farmers. Importantly, the findings from this study can help guide development interventions, on the best way to frame an approach that will engender better climate change adaptation among farmers in the coastal regions in the developing nations and beyond.

The rest of the paper is structured as follows: Section 2 presents the theories underlying determinants of adaptation strategies, Section 3 describes the methodology used in the study, Section 4 presents the empirical results, followed by section 5 which details our conclusions and policy implications.

## 2. THEORY UNDERLYING DETERMINANTS OF ADAPTATION STRATEGIES: UTILITY MAXIMIZATION AND PROTECTION MOTIVATION

For explaining the choice of adaptation strategies adopted by households, the utility maximization theory is used. Households are assumed to be rational beings; hence they choose adaptation options that maximize their expected utility among the available options (Amare & Simane, 2017; Gebrehiwot & van der Veen, 2013; Menozzi et al., 2015). The limitation of this theory is that in the real world this may not always apply as there are other factors that may affect the behaviour of households. If $U_i$ and $U_j$ represent the household's utility for any two adaptation options. Following Greene (2000) the random utility model can be stated thus:

$$U_{it}=V_{it}+\varepsilon_{it},\ U_{jt}=V_{jt}+\varepsilon_{jt} \quad 2.1$$

where $U_{it}$ and $U_{jt}$ are the perceived utility from choosing adaptation options i and j at time t respectively; $V_{it}$ and $V_{jt}$ are the deterministic component and $\varepsilon_{it}$ and $\varepsilon_{jt}$ are the error terms of the utility function which are independently and identically distributed. Utility cannot be directly observed, it is rather indirectly observed from the choices that households make. Choice experiments assume that a household m chooses an option i at time period t, only if this adaptation option generates at least as much utility as any other option for example j, represented as:

$$U_{mit}>U_{mjt},\ j\neq i \quad 2.2$$

The probability of a household m choosing adaptation option i among the available adaptation strategies at time t can then be specified as:

$$P_{mit}=P(U_{mit})>U_{mjt}),\ j\neq i \quad 2.3$$

The second theory, which has been found to be valuable in explaining adaptive behaviours of individuals to climate change is the protection motivation theory (Cismaru et al., 2011). The theory of protection motivation was originally postulated by Rogers (1975) and applied in the field of health to explain how individuals are motivated to act in a protective manner toward a perceived health risk. However, it has since been adapted and applied in other contexts such as environmental risk and natural hazards. For instance, it has been applied to the studies of natural hazards such as earthquakes in the United States (Mulilis & Lippa, 1990), and flood in Germany and the Netherlands (Grothmann & Reusswig, 2006 and Bubeck, Botzen, Kreibich, & Aerts, 2013) and even studies on climate change adaptation (Grothmann & Patt, 2005; Keshavarz & Karami, 2016; Koerth, Vafeidis, Hinkel, & Sterr, 2013; Bockarjova & Steg, 2014). This theory postulates that individuals will act to protect themselves against a perceived risk if they perceive that the threat of that hazard, they are exposed to is severe (threat appraisal) and if the coping appraisal is high. Threat appraisal is composed of two main components: 'perceived vulnerability' (probability) and 'perceived severity' (consequences). Coping appraisal, on the other hand, consists of three components namely: 'response efficacy', 'self-efficacy' and 'response cost'. The coping appraisal is considered high if individuals perceive the protective measures available to be effective *i.e.*, able to mitigate the threat (high 'response efficacy'), easy i.e., the individuals perception of their ability to implement the required actions (high 'self-efficacy') and inexpensive (low 'response costs') (Floyd et al., 2000). The two appraisal processes influence an individual's protection motivation (Maddux & Rogers, 1983; Opata et al.,

2021). However, Poussin et al. (2014) found that coping appraisal has a far-reaching effect on self-protective bahaviours by individuals than threat appraisal. Grothmann & Reusswig (2006) in their study concluded that it is just not enough to communicate the threat or risk individuals are exposed to (threat appraisal) but the benefits and cost of precautionary measures (coping appraisal) should also be included.

In this study, this theory can be adapted to explain the behaviour of households to act in a protective manner towards the perceived threat to their livelihoods occasioned by environmental and social factors (climate shock, environmental degradation, and conflict). There are two processes. In the first process, 'threat appraisal' the household assesses the threat probability for example climate shocks and the severity of the damage that will be done say to their food security or income should they choose not to act. The second process is the 'adaptation appraisal' that has three components. The first is the 'perceived adaptation efficacy', which is the perception of the effectiveness of the adaptive action in protecting one from the threat (e.g., a judgment that changing crop variety can protect one from climate shocks). The second component is the 'perceived self-efficacy which refers to the household's perceived ability to implement the adaptive action (e.g., a household might perceive that they lack the technical skills to implement a particular innovation). The third component is the 'perceived adaptation cost', which refers to the cost of taking the adaptive action (such as monetary, time, effort). Based on the outcome of these two processes the household responds to the threat. Two responses are possible: adaptation and maladaptation, while the former reduces the damage from the threat, the latter increases the damage. Some examples of maladaptive responses are denial of the threat and wishful thinking (Grothmann & Patt, 2005). One major limitation of this theory is that it does not take into account all of the cognitive and contextual factors, including the influence of social norms.

## 3. METHODOLOGY

### *3.1 Description of the study area and sampling*

The study area is Niger Delta region. It is located at latitudes 4˚25'N to 6˚00'N and longitudes 5˚00'E to 7˚5'E (PEDI, 2020). It is situated on the Atlantic Coast of southern Nigeria where the River Niger divides into many branches (Uyigue and Agho 2007). It is the second biggest delta in the world having a coastline covering around 450 kilometers which ends at the mouth of Imo River (Awosika 1995). The region is divided into four ecological

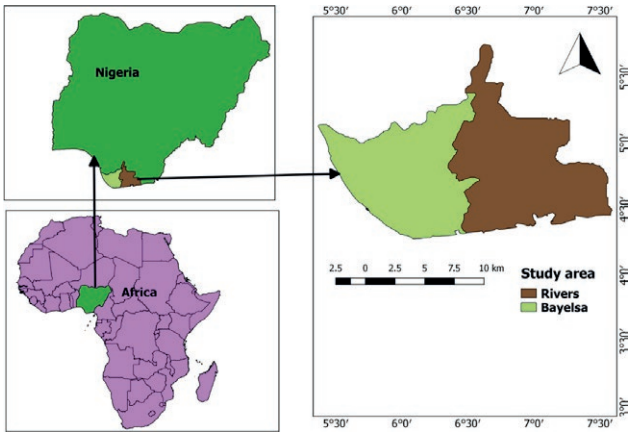


**Figure 1.** Map of Nigeria showing the study area.

zones namely coastal inland zone, mangrove swamp zone, freshwater zone, and lowland rain forest zone.

The Niger Delta region officially comprises nine states namely, Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and River States. It has about 185 local government areas (LGAs) and over 40 ethnic groups in an estimated 3000 communities (PEDI, 2020). The region has an estimated population of about 36 million (World meter 2020), and the large majority depend on fishing and farming as a means of livelihood. Figure 1 below shows the map of Nigeria showing the two states in the Niger Delta region where data for the study was collected.

A multi-stage sampling technique was used in selecting the households used in the study. In the first stage, 2 states were purposively selected out of the nine states due to their dependence on farming and fishing, and the coastal nature of the states which predisposes them to frequent flooding and coastal erosion. In the second stage 13 local government areas (LGAs) out of 23 LGAs were selected from Rivers State purposively due to the predominance of agricultural activities and 4 LGAs out of 8 LGAs were selected from Bayelsa state. In the third stage proportional random sampling was used to select 18 and 8 communities from the selected LGAs in Rivers and Bayelsa states respectively. In the fourth stage, proportional random sampling was used in selecting the 251 farming households and 252 fishing households. A total of 503 household heads were interviewed and where the household head was not available the next available adult was interviewed. We are aware that the choice to interview the next available adult where the household head was not available could have impacted the results in some ways, but we cannot comment on the magnitude of any potential selection bias.

The United Nations (2005 p. 44-45) sample size formula (see equation 3.1) was used to determine the number of households selected for the study. Using a confidence interval (Z) of 95%, 50% default value of prevalence of indicators (r), a sample size of 430 households was required. However, to account for possible missing values and outliers, the sample size was increased to 510. In the end, only 503 of the questionnaires were valid and were used for the analysis.

$$N = \frac{[(Z^2)(r)(1-r)(f)(k)]}{[(p)(n)(e^2)]} \quad 3.1$$

Where: N= sample size,
Z = confidence interval (95% level is 1.96),
r = estimate of key indicators being measured (default value is 0.5),
f = sample design effect (has a default value of 2),
k = multiplier accounting for non-response (1.1),
p= proportion of the total population accounted for by the target population (0.4),
n = mean of household size (5),
e = precision level (10% precision level equals 0.01r)

*3.2 Data collection*

Both secondary and primary data were collected for the study. The secondary data on temperature and rainfall were collected from the Nigerian Meteorological Agency (NIMET). The primary data on quantitative information was obtained from households of farmers and fishermen. Structured questionnaires were employed. To ensure the reliability and validity of the survey instrument, the survey instrument was given to 3 experts for validation. Questionnaires were pre-tested on 10 respondents and modifications were done where necessary before actual data collection (e.g., we modified the framing of some questions that appeared ambiguous to better target the goal of the study). The questionnaires were administered between March and April 2018. The questionnaires had sections on household socio-demographic and institutional characteristics, perceptions of climate shocks and impact, and adaptation strategies (for a detailed description of the type of questions asked see supplementary materials). The secondary data comprises annual temperature and rainfall data for the region for the period between 1982 and 2018. Rainfall was measured in millimeters (mm) and temperature in degrees Celsius (°C). For ethical considerations, we included an informed consent form to the introductory note on the purpose of the survey and the survey team used it to obtain verbal consent of each respondent's willingness to participate in the survey.

*3.3 Econometric estimation*

To identify adaptation strategies employed by the two livelihood groups descriptive statistics such as percentages were employed. First, the respondents were asked if they've experienced any changes in the temperature and rainfall pattern in the last 30 years. Where the answer is yes, a follow question is asked on the strategies used to adapt to these changes. Some of the respondents reported having been using some of the management practices before the changes but had to intensify their use with the recent changes in climate, while some reported that they only started using the management practices in response to the climate change. In this study the adaptation strategies employed by farmers have been grouped into three namely: soil and water management, crop management and livelihood diversification while adaptation strategies employed by fishermen have been grouped into two: intensification and livelihood diversification.

To determine factors influencing choice of adaptation strategies by the two livelihood groups the multinomial logit model was used. The multinomial logit and multinomial probit models are usually used to analyse adoption decisions involving multiple choices such as adaptation decisions that are made jointly (Wooldridge, 2002 Madalla, 1983). Given the myriads of possible drivers of climate change adaptation, Zucaro et al., (2021) propose the need for applying multi-criteria analysis to select the most effective climate change adaptation measures. However, the choice of the multinomial logit model over the multinomial probit is because it is computationally easier to calculate the choice probabilities which are expressible in analytical form (Tse, 1987). It provides a suitable closed form for underlying choice probabilities, ruling out the need for multivariate integration and this makes it easy to compute choice situations with several alternatives. The computation is also made easier as a result of its likelihood function which is globally concave (Hausman & McFadden, 1984). The limitation of the model is the independence of irrelevant alternatives (IIA) property. This assumption states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Hausman & McFadden, 1984; Tse, 1987). Specifically, this assumption means that the probability of using a particular adaptation strategy by a household should be independent of the probability of choosing another adaptation strategy. Hausman test was used to judge the validity of the assumption. The test is based on the fact that if an alternative is irrelevant, removing an alternative or several alternatives from the model should not change the

coefficients systematically. The result of the Hausman tests of IIA assumption (Appendix 1 and 2) showed that null hypothesis: Odds (Outcome-J vs Outcome-K) are independent of other alternatives (P>chi2 =.), hence does not violate the assumption that the probability of using a particular adaptation strategy by a household should be independent of the probability of choosing another adaptation strategy.

To describe the multinomial logit model let $A_i$ denote a random variable representing the adaptation strategy adopted by any household (already identified). We assume that each household faces a set of discrete, mutually exclusive options for adaptation strategies. These strategies are assumed to depend on a number of households, institutional, environmental and other attributes X. The multinomial logit model specifies the relationship between the probability of choosing alternative $A_i$ and the set of explanatory variables X as seen in equation 3.2 (Greene, 2003):

$$Prob(A_i = \text{j}) = \frac{e^{\beta_j x_i}}{1+\sum_{k=1}^{j} e^{\beta_k x_i}}, j = 1,2 \ldots . J \qquad 3.2$$

In this study the adaptation strategies employed by farmers have been grouped into three namely: soil and water management, crop management and livelihood diversification while adaptation strategies employed by fishermen have been grouped into two: intensification and livelihood diversification. The independent variables used in the model are listed in Table 3.1.

Estimating equation 3.2 gives the J log-odds ratio in equation 3.3.

$$\ln\left(\frac{\partial P_j}{\partial x_i}\right) = x_i'(\beta_j - \beta_k) = x_i'\beta_j, \; if \; k = 0 \qquad 3.3$$

The coefficient $\beta_j$ of the multinomial logit model only shows the direction of the effect of the explanatory variable on the dependent variables (adaptation option) and does not provide the actual magnitude of the change or probability. Therefore, differentiating equation (3.2) above with respect to the independent variables gives the marginal effects of the independent variables and is stated in equation 3.4:

$$\frac{\partial P_j}{\partial x_i} = P_j\left(\beta_j - \sum_{k=0}^{J} P_k \beta_k\right) \qquad 3.4$$

Marginal effects measure the expected change in the likelihood of a particular adaptation strategy being chosen with respect to a unit change in an explanatory variable from the mean (Greene, 2000). The signs of the marginal effects and respective parameter estimates may vary, this is because marginal effects depend on the sign and magnitude of all other parameter estimates. Some studies (e.g., Amare & Simane, 2017; Atinkut & Mebrat, 2016; Deressa, Hassan, Ringler, Alemu, & Yesuf, 2009; Gunathilaka, Smart, & Fleming, 2018) have adopted the multinomial logit model to assess the determinants of adaptation strategies employed.

### *3.4 Model specification*

Household socio-economic, institutional, farm level, environmental and location characteristics were hypothesized to influence the choice of adaptation strategies employed. The following explanatory variables were considered in the multinomial model: educational level, household size, age of household head, years of experience in farming/fishing, sex of household head, household income, access to extension services, membership of association, access to information on climate change, access to credit, farm size, perception of shift in temperature, perception of shift in rainfall and location. The empirical model is stated in equation 3.5.

$$\boldsymbol{ADS_i = B_0 + B_n S_n + B_m I_m + B_z I_z} \qquad \textbf{3.5}$$

Where $ADS_i$ denotes the adaptation strategies employed by farming or fishing households, S, B and I represent the sociodemographic, institutional, and climatic factors, respectively. $B_0$ denotes the intercept; $B_n$, $B_m$ and $B_z$ denote the parameters estimates for each sociodemographic (n), institutional (m) and climatic (z) factor.

A description of the explanatory variables used in the model, the measurement and the apriori expectation has been presented in Table 1.

## 4. RESULTS AND DISCUSSION

### *4.1 Household characteristics and climatic patterns*

Descriptive results are presented in Table 2 and Figures 2-5. Based on the results, about 62% of the sampled households were male-headed households, the majority (77.3%) of them were married and only a few (3%) of them had no formal education. This profile on marital status is higher than the national average, where about 58% of the population are married, but lower in terms of education where literacy rate reached 77.62% in 2021 (Statistica, 2022). Most (94%) of the households had no access to extension services, no access to credit (about

**Table 1.** Description of explanatory variable and hypothesized signs.

| Variable | Description | Measure | Apriori expectation |
|---|---|---|---|
| *Sociodemographic factors* | | | |
| Educ | Years of education | Continuous (years) | + |
| HHsize | Size of household | Continuous (number) | +/- |
| Age | Age of household head | Continuous (years) | +/- |
| Exp | Farming/fishing experience | Continuous (years) | +/- |
| Sex | Sex of household head | Dummy (1=male, 0=female) | +/- |
| HHincome | Household income | Continuous (naira) | + |
| Fsize | Farm size | Continuous (hectares) | +/- |
| *Institutional factors* | | | |
| Ext | Access to extension services | Dummy (1=yes, 0=no) | + |
| Asso | Membership of association | Dummy (1=yes, 0=no) | + |
| Info | Information on climate change | Dummy (1=yes, 0=no) | + |
| Cred | Access to credit | Dummy (1=yes, 0=no) | + |
| *Climate factors* | | | |
| Temp | Perception of shift in temperature | Dummy (1=yes, 0=no) | + |
| Rain | Perception of shift in rainfall | Dummy (1=yes, 0=no) | + |
| State | Location | Dummy (1=Bayelsa, 0=Rivers) | +/- |

Source: Author.

88%) and do not belong to any farmer/fisher-based association (89%). This finding corresponded to the national average as reported in Emeana (2017) who reported a farmer to extension service ration of 1:10. About 79% of the households had access to health care which is lower than the national average where over 90 percent of Nigerian households reported being able to access necessary healthcare (Statistica, 2022). About 51% of the households were engaged in off-farm work, this is close to the national average as reported in Ume, Nuppenau and Domptail (2022). On average, the sampled household heads were aged 48 years, had 9 years of schooling, a household size of 7, a farming/fishing experience of 25 years, and farm size (for farming households) of 0.3 hectares. There were no significant differences in the age, experience, household size, access to credit, and access to climate information by farming and fishing households which is evident from the two samples mean comparison test. However, there were significant differences in the gender, years of schooling, membership in social networks, access to extension services, household income, and perception regarding changes in temperature and rainfall by farming and fishing households.

Responses on farmers' perception about long-term temperature and rainfall changes (Figure 2) show that majority (84.46%) of the surveyed households perceived that the temperature has increased over the last 20 years, 12.75% perceived that it has decreased while the remaining 2.79% did not perceive any change. On the other hand, majority (63.49%) of the respondents perceived that precipitation has decreased, 31.75% perceived that there has been an increase in rainfall while the remaining 4.76% have not observed any change. The perception of households regarding climate shocks has serious implications as to whether to adapt or not and the type of adaptation strategies to adopt. Households cannot adapt to what they do not perceive or experience. Some studies show that farmers who perceive or experience climate related risks are more likely to plan for adaptation (Al-Amin et al., 2019; Habtemariam et al., 2020; Mahmood et al., 2021)

Furthermore, descriptive analysis presented the annual temperature and rainfall data for the region for the period between 1982 and 2018 as shown in Figures 3, 4, and 5. This also validated the local perception of the long-term change in temperature and rainfall. This aligns with the findings of Mahmood et al., (2021) who found that the farmers' perception of the local climate was consistent with historical meteorological trends of temperature and rainfall from 1980 to 2017.

The rainfall data showed a large negative deviation compared to their long-term means (dotted lines) for most years particularly between 1982-1983 and 1992-1998 indicating high rainfall variability (Figure 3). The rainfall data revealed that the annual rainfall increased by 2.29 mm every decade. This result does not corroborate the local perception of observed decrease in rainfall. However, the findings are consistent with Koomson et

**Table 2.** Summary statistics of household characteristics.

| Variables | Description | Full sample Mean | Farmers Mean | Fishers Mean | t-test *t*-value |
|---|---|---|---|---|---|
| Age | Age of HH head (years) | 47.75 (12.60) | 47.48 (13.48) | 48.02 (11.68) | -0.48 |
| Gender | Gender of HH head (1= male; 0 = female) | 0.62 (0.49) | 0.39 (0.49) | 0.86 (0.35) | -12.31*** |
| Experience | Farming/fishing experience of HH head (years) | 24.97 (13.81) | 25.19 (14.74) | 24.75 (12.86) | 0.36 |
| Household size | Number of HH members | 7.42 (2.55) | 7.41 (2.74) | 7.43 (2.36) | -0.10 |
| Education | Formal education of HH head (years) | 9.07 (4.50) | 9.61 (4.63) | 8.54 (4.30) | 2.69*** |
| Access to credit | HH had access to credit services (1 = yes, 0 = no) | 0.12 (0.33) | 0.15 (0.36) | 0.10 (0.30) | 1.65 |
| Social network | HH had membership in local organization (1= yes, 0 = no) | 0.11 (0.31) | 0.15 (0.36) | 0.07 (0.25) | 2.92*** |
| Extension | HH had access to extension services (1= yes, 0 = no) | 0.06 (0.24) | 0.08 (0.28) | 0.04 (0.19) | 2.28** |
| Access to climate information | HH had access to information on climate (1=yes, 0=no) | 0.49 (0.50) | 0.49 (0.50) | 0.50 (0.50) | -0.13 |
| Farm size | Size of land cultivated (hectare) | - | 0.63 (0.54) | - | - |
| Household income | Total HH annual income (₦) | 821805.2 (718922) | 610908.5 (529628) | 1031865 (815801) | -6.86*** |
| Perception of shift in temperature | HH perceived that temperature has changed over the last 30 years (1 = yes, 0 = no) | 0.78 (0.42) | 0.88 (0.33) | 0.68 (0.47) | 5.25*** |
| Perception of shift in rainfall | Perception of change in rainfall has changed over the last 30 years period (1 = yes, 0 = no) | 0.64 (0.48) | 0.74 (0.44) | 0.53 (0.50) | 4.99*** |
| Location | HH located in Bayelsa (1= Bayelsa, 0 = otherwise) | 2.99 (1.00) | 3.00 (1.00) | 3.00 (1.00) | 0.04 |
| | HH located in Rivers (1= Rivers, 0 = otherwise) | 2.99 (1.00) | 3.00 (1.00) | 3.00 (1.00) | - 0.04 |

Note: ***, ** and * indicate 1%, 5% and 10% level of significance respectively; 1 USD = ₦380; Values in parenthesis are standard deviations.
Source: Field survey, 2018.

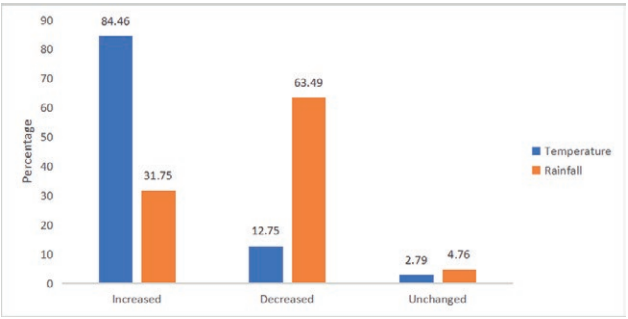


**Figure 2.** Local perception of long-term temperature and rainfall changes. Source: Field survey (2018).

al. (2020), who showed an overall increase in rainfall in the last decade in Effutu Municipality, Ghana from 1989 to 2018.

As expected, the minimum temperature data showed less dramatic variability over time with overall warming being noticeable, particularly in the middle of the temporal span (Figure 4). The period between 1989 and 2012 had lower temperatures than the annual mean minimum temperature of 22.4°C. The analysis of the descriptive results further showed that the mean annual minimum temperature increased by 0.01°C every decade. The annual mean maximum temperature (Figure 5) shows a more dramatic variability over time than the annual minimum temperature and is increasing at a faster rate of 0.02°C per decade. The annual mean temperature shows a less dramatic variability over time than the annual maximum temperature and is increasing at a rate of 0.01°C per decade. This evidently shows that the days are warming over time. From the analysis of the temporal data, it can be inferred that the local percep-

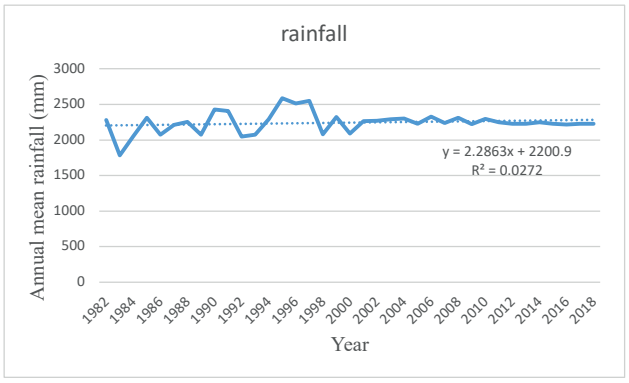


**Figure 3.** Interannual variability in rainfall in the study area between 1982-2018. Source: Author's creation from CRU climate data.

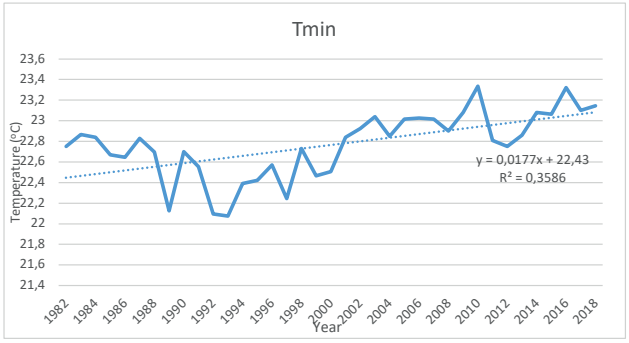


**Figure 4.** Interannual variability in minimum temperature in the study area between 1982 and 2018. Source: Author's own creation from CRU climate data.

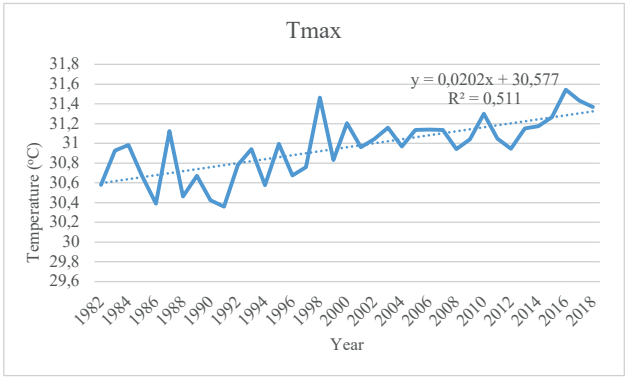


**Figure 5.** Inter-annual variability in maximum temperature in the study area between 1982 and 2018. Source: Author's own creation from CRU climate data.

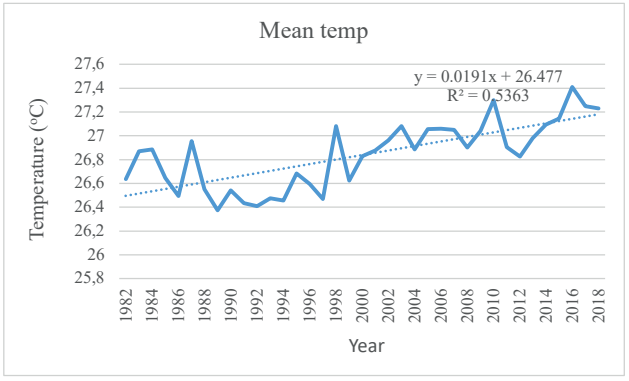


**Figure 6.** Inter annual variability in mean temperature in the study area between 1982 and 2018. Source: Author's creation from CRU climate data.

tion of climate variability agreed with the historical data on temperature.

### *4.2 Adaptation strategies to climate shocks*

The adaptation strategies the farming households employed were grouped into three (3) categories for computational ease. They include soil and water management, crop management, livelihood diversification, and the 'no adaptation' option, which was used as the base category in the MNL. In this study, the following adaptation strategies (cover crops, deep tillage, hedging, mulching, ridge cultivation, and run-off harvesting) were grouped into the soil and water management component (SWM). Crop rotation, crop diversification, agroforestry, changing of planting and harvesting dates, use of improved and drought resistant varieties were grouped under crop management component (CM). Engagement in off-farm and non-farm activity was grouped under livelihood diversification component (LD). Majority (78.5%) of the surveyed farming households used livelihood diversification as an adaptation option (Table 3). This is followed by crop management (77.7%) and soil and water management options (64.5%). However, 10% of the farming households mentioned that they do not use any adaptation strategies. Similar studies which have found that farmers adopted some of the above-mentioned strategies are (Khanal et al., 2018; Mahmood et al., 2021; Owusu et al., 2021; Shikuku et al., 2017).

Furthermore, the adaptation strategies the fishing households employed were categorized into two: intensification and livelihood diversification for the purpose of computational ease (Table 3). Use of improved gears, extension of working hours, varying fishing locations and fishing over large expanses were grouped as intensification. Engagement in off-fishing and non-fishing activities were grouped as livelihood diversification. The 'no adaptation' option was included in the

**Table 3.** Adaptation strategies employed by farming and fishing households in the study area.

| Adaptation options | Frequency | Percentage (%) |
|---|---|---|
| *Farmers* | | |
| **Soil and water management (SWM)** | 162 | 64.54 |
| Cover crops | 106 | 42.23 |
| Deep tillage | 130 | 51.79 |
| Hedging | 58 | 23.11 |
| Mulching | 33 | 13.15 |
| Ridge cultivation | 69 | 27.49 |
| Run-off harvesting | 12 | 4.78 |
| **Crop management (CM)** | 195 | 77.69 |
| Crop rotation | 118 | 47.01 |
| Crop diversification | 143 | 56.97 |
| Agroforestry | 12 | 4.78 |
| Changing of planting and harvesting date | 168 | 66.93 |
| Improved and drought resistant varieties | 157 | 62.55 |
| **Livelihood diversification (LD)** | 197 | 78.49 |
| *Fishing households* | | |
| **Intensifying fishing efforts** | 49 | 80.33 |
| Using improved fishing gear | 36 | 59.02 |
| Extending working hours | 41 | 67.21 |
| Varying fishing location | 25 | 40.98 |
| Fishing over large expanse | | |
| **Livelihood diversification** | 51 | 83.61 |

Note: multiple responses indicated.
Source: Field Survey (2018).

computation of factors influencing choice of adaptation strategies. Majority (83.61%) of the surveyed fishing households used livelihood diversification as an adaptation option. This is followed by use of improved gears (80.33%) and varying fishing locations (67.21%) while the least used strategy was fishing over large expanse (40.98%). Similar studies which reported fishers using the afore mentioned adaptation strategies are (Deb & Haque, 2017; Galappaththi et al., 2019, 2021; Kabisa & Chibamba, 2017; Mabe & Asase, 2020; Yanda et al., 2018).

### *4.3 Determinants of choice of adaptation strategies*

#### 4.3.1 Determinants of choice of adaptation strategies by farming households

The decision to choose a certain adaptation strategy is based on several socio-demographic, economic, institutional, and biophysical factors, which are estimated using the multinomial logit model. The results of the multinomial logit model are presented in Table 4. The marginal effects of all the explanatory variables have been reported.

The results indicate that age of household head positively and significantly affected the probability of adopting soil and water management practices as an adaptation strategy at probability level of 0.05. The magnitude of this effect is 0.003. This suggests that the likelihood of adopting soil and water management practices increases by 0.3% for every year of household head age. A plausible explanation for this result is that older farmers are more experienced and more likely to experience changes in climate and therefore, adopt adaptation strategies to cope with the change. For instance, the study by Al-Amin et al. (2019) showed that older women were more likely to perceive climate change than younger women. Previous studies that reported that age positively affected the adoption of adaptation strategies to climate change include Adimassu & Kessler (2016); Opiyo et al., (2016); Alemayehu & Bewket (2017) and Belay & Fekadu (2021), while others like Kassim, Alhassan, & Appiah-Adjei (2021) and Ali & Erenstein (2017) contradicted the results by reporting negative and significant relationship of age with early planting adaptation strategies in Ghana and crop management (*i.e.*, adjustment in sowing time, drought-tolerant varieties and shift to new crops) in Pakistan.

The result shows that gender of household head exerts a positive and significant ($p<0.1$) influence on the adoption of soil and water management practices. This means that male-headed households are 13% more likely to use soil and water management practices as an adaptation strategy than female headed households. This is probably because male-headed households have better access to resources and information as well as higher decision power to make decisions regarding adaptation. Previous studies that corroborate these findings include Asfaw & Admassie (2004), Deressa et al., (2014), Deressa et al., (2009) Mahmood et al., (2021). On the other hand, gender was found to influence the adoption of livelihood diversification as an adaptation strategy negatively and significantly ($p<0.1$). The marginal effect of the variable is -0.1841. This means that female-headed households had an 18% higher chance of adopting livelihood diversification as an adaptation strategy. This result is in agreement with the findings of Amare & Simane (2017) and (Kassim et al., 2021) who found that female headed households diversified more and are more likely to engage in off-farm activities. However, it contradicts the findings of Asfaw et al., (2017) and Rahman & Akter (2014) who found that males adopted non-farm livelihood diversification more than females because of their involvement in household chores which leaves them with little or no time to engage in off-farm activities.

Household size was found to influence the adoption of crop management practices positively and sig-

**Table 4.** Multinomial regression results for determinants of adaptation strategies by farming households.

| Explanatory variables | Soil and water management Marginal effects | Crop management Marginal effects | Livelihood diversification Marginal effects |
|---|---|---|---|
| Age | 0.003** | -0.002 | 0.000 |
| | (0.061) | (0.015) | (0.019) |
| Gender | 0.127* | 0.023 | -0.184* |
| | (1.164) | (-0.326) | (-0.889) |
| Household size | -0.0135 | 0.089*** | -0.061 |
| | (-0.048) | (0.353) | (0.002) |
| Education | 0.006* | 0.023** | -0.021 |
| | (0.188) | (0.142) | (0.036) |
| Access to credit | -0.067*** | 0.113 | 0.036 |
| | (-0.226) | (1.672) | (1.532) |
| Social network | -0.559** | -0.028 | 0.131 |
| | (-0.583) | (0.619) | (0.985) |
| Extension | 0.113 | 0.037 | -0.218*** |
| | (0.148) | (-0.849) | (-1.983) |
| Access to climate information | 0.036 | -0.136* | 0.112 |
| | (0.689) | (-0.168) | (0.422) |
| Farm size | 0.091** | -0.042 | 0.218*** |
| | (-0.433) | (0.867) | (1.517) |
| Perception of shift in temperature | -0.018 | 0.036 | -0.039 |
| | (-0.507) | (-0.177) | (-0.355) |
| Perception of shift in rainfall | 0.015 | 0.181** | -0.211 |
| | (0.074) | (0.271) | -0.661 |
| Constant | -4.695** | -3.684 | -0.013 |
| Diagnostics | | | |
| Number of observations | 251 | | |
| LR(33) | 128.64 | | |
| Prob > chi2 | 0.0000 | | |
| Log likelihood | -240.00978 | | |
| Pseudo $R^2$ | 0.2113 | | |

Note: Base category: no adaptation; ***, ** and * indicate significance at 1%, 5% and 10% respectively. Values in parentheses are the standard errors.
Source: Field survey (2018).

nificantly ($p<0.01$). As household size increases by one the probability that the household will adopt crop management practices increases by 8.9%. This is probably because activities involved in crop management are capital intensive and so only large households size who have household members engaged in other income generating activities that generate extra income to invest in this adaptation option. In addition, it is understandable that large households would like to engage their workforce in different income generating activities and hence are more likely to diversify. Another reason could be that most agricultural activities in Nigeria are labour intensive due to low mechanization; large household size therefore constitutes a source of labour to enable households engage in adaptation practices and other agricultural practices such as tree planting, soil conservation and other crop management practices. This result is in agreement with the findings of Shikuku et al., (2017), Ali & Erenstein (2017), Habtemariam et al., (2020) and Diallo, Donkor, & Owusu (2021) who found that large households are more likely to adopt adaptation strategies such as changing planting date, improved varieties and planting of trees.

The variable education exerts a positive and significant effect on farming households' decision to adopt soil and water management and crop management practices as an adaptation strategy to climate shocks albeit at the 10% and 5% levels. The marginal effects result thus indicates that an increase in the year of schooling by 1 year increases the probability that households will adopt soil and water management and crop management practices by 0.6% and 2.3% respectively. This is expected as education provides more understanding as to the impacts of climate change as well as adaptation methods to

be adopted to be able to cope with these impacts. This result is in agreement with previous studies such as Alauddin & Sarker (2014), Alam et al., (2016), Khanal et al., (2018), Belay & Fekadu, (2021) Mahmood et al., (2021) and Kassim et al., (2021) which reported the positive influence of education on adaptation.

Interestingly, access to extension services was found to exert no significant influence on the adoption of soil and water conservation and crop management but was found to exert a significant ($p<0.05$) and negative effect on the adoption of livelihood diversification as an adaptation strategy. This means that households with no access to extension services are 21.8% more likely to adopt livelihood diversification as an adaptation strategy. This is contrary to apriori expectations as extension agents are expected to be at the forefront of communicating climate information and innovations in agriculture. A plausible explanation for the negative effect could be that households with no access to extension services are equipped with information on other adaptation strategies such as off-farm activities that they could choose. Another plausible explanation could be the weakness of the extension delivery system typically in most African countries as pointed out by Oladele & Sakagami (2004) and Antwi-Agyei & Stringer (2021) which include poor financial decentralization, inadequate use of alternative extension methods, lack of knowledge on climate change by extension agents, high bureaucratic setting and inadequate cooperation and coordination with other agencies. Most previous studies such as (Al-Amin et al., 2019; Alemayehu & Bewket, 2017; Ali & Erenstein, 2017; Habtemariam et al., 2020; Kassim et al., 2021) have often reported positive effects of extension service on adoption of adaptation strategies such as use of improved varieties, soil and water conservation practices. However, our finding is consistent with the findings of Owusu et al., (2021) and Shikuku et al., (2017) who reported a negative effect of extension services on adoption of adaptation strategies.

Farm size was found to exert a positive and significant influence on farming household decisions to adopt soil and water management practices and livelihood diversification as an adaptation strategy to climate shocks at 5% and 1% levels respectively. A unit increase in farm size increases the chances of adoption of livelihood diversification and soil and water management practice as an adaptation strategy by 22% and 9.1% respectively. This means that households with larger farm sizes were more likely to diversify more probably to generate additional income for adaptation and expand production. They are more likely to have capacity to invest in climate shock adaptation options. It could also be that farming households with large farm sizes are more worried about the impact of climate shocks since they are more likely to lose a larger proportion of their output compared to those with smaller farm sizes and so are not willing to take the risk. Hence, their eagerness to adopt livelihood diversification and soil and water management practices to off-set any adverse effects. This result contradicts the findings of Deressa et al., (2011); Bazezew et al., (2013) and Gebreyesus (2016) that reported that farm size negatively affects the probability of using livelihood diversification as an adaptation measure. However, it agrees with the findings of (Al-Amin et al., 2019; Ali & Erenstein, 2017; Kassim et al., 2021) who reported positive effect of farm size on adaptation strategies such as upland planting, planting of horticultural crops and improved varieties.

Another interesting finding is access to credit which was found to exert negative and significant effect on the probability to adopt soil and water conservation as an adaptation strategy at 1%. This means that credit constrained households are 6.7% more likely to take up soil and water conservation as an adaptation strategy. This finding is consistent with the findings of Teklewold et al., (2019) who found that households with lack of access to credit are more likely to take up soil conservation practices. However, it contradicts studies such as Al-Amin et al., (2019), Diallo et al., (2021), Shikuku et al., (2017), Belay & Fekadu, (2021) which all argued that households with access to credit are more likely to take up adaptation strategies such as soil and water conservation and crop management practices since access to capital is a major deciding factor in the choice to adopt an innovation and hence required to facilitate adoption of adaptation strategies.

Again, the variable social network also showed some interesting results. It was found to exert a negative and significant influence on the adoption of soil and water management practices as an adaptation strategy against climate shocks at a 5% level. This means that those who do not belong to any farmer-based organizations or groups are 55.9% more likely to adopt soil and water conservation as an adaptation strategy. This is contrary to apriori expectation since studies such as Teklewold et al., (2019), and Owusu et al., (2021) have shown that social capital networks positively influence adoption of adaptation strategies and innovation. The reason for the negative influence could be that the farmers belonged to several organizations and received conflicting climate change information from several sources. However, our finding is consistent with the findings of Belay & Fekadu (2021), Diallo et al., (2021) and Al-Amin et al., (2019) who found that social capital negatively influences farm-

ers' adoption of climate change adaptation strategies such as fertilizer, short duration and drought tolerant varieties.

Perhaps again somewhat surprisingly, access to information was found to exert negative and significant effect on the adoption of crop management as an adaptation strategy albeit at a 10% level. This means that those who do not have access to climate information are 13.6% more likely to employ crop management as an adaptation strategy. There are mixed findings about the effect of climate information on adaptation strategies. Access to climate information has been found by some studies such as Kassim et al., (2021), Khanal et al., (2018), Alam et al., (2016) to promote adoption of adaptation strategies. However, Owusu et al., (2021) found no significant impact of the use of climate information on the adoption of adaptation strategies in response to climate change. Our finding corroborates the findings of Teklewold et al., (2019) who found that climate information negatively influences the adoption of soil conservation as an adaptation strategy.

Finally, the variable perception of a shift in rainfall showed a positive and significant influence on the adoption of crop management as an adaptation strategy. This means that households who perceived that there has been a change in rainfall are 18.1% more likely to adopt crop management as an adaptation strategy. Our finding aligns with other studies like Khanal et al., (2018), Kassim et al., (2021) Al-Amin et al., (2019) Owusu et al., (2021) who all argue that households who perceive and experience climate change are more likely to adopt adaptation strategies to respond to the adverse effect of climate change.

### 4.3.2 Determinants of choice of adaptation strategies by fishing households

Studies have shown that farmers' attitudes perceived behavioral control and past behavior are very important in predicting intentions to adopt the private sustainability schemes (Menozzi et al., 2015). This means that the decision to choose a certain adaptation strategy is based on several socio-demographic, economic, institutional and biophysical factors. The results of the multinomial logit model are presented in Table 5. The results indicate that education of household heads positively and significantly affected the probability of adopting intensification of fishing efforts and livelihood diversification as an adaption strategy at 1% and 5% levels respectively. This means as years of schooling of household head is increased by one year the probability of adopting intensification increases by 1.5% and livelihood diversification by 0.9%. Higher education is associated with greater access to information and skills to adopt adaptation strategies and innovation (Belay & Fekadu, 2021). This result agrees with previous studies such as Sereenonchai & Arunrat, (2019) and Alam et al., (2016) which reported that education positively influences adaptation choices.

Access to climate information was found to have a significant negative influence on the choice of intensification as an adaptation strategy by fishing households at a 5% level. This means that fishing households who do not have access to climate information are 7% more likely to adopt intensification as an adaptation strategy. This result is contrary to some studies like Mabe & Asase, (2020) and Sereenonchai & Arunrat (2019) which asserts that fishing households with access to climate information are more likely to adopt adaptation strategies to avert the adverse effect of climate change.

As expected, the results of the study showed that household income positively and significantly influences the probability of adopting livelihood diversification as an adaptation strategy at a 5% significance level. This means that as income increases, the probability of households diversifying their sources of livelihood increases. This may be because of the availability of capital to invest in other non-fishing activities to reduce the risk that climate shock poses to their fishing livelihood. This result is supported by the findings of Sereenonchai & Arunrat, (2019) who showed that an increasing non-fishing income increases the probability of adopting adaptation strategies. Findings from Meressa & Navrud, (2020) also showed that farmers' adoption of new varieties could be greatly increased by incorporating traits that are in high demand, suggesting the need for increased income in increasing farmers' adoption of new technology.

The variable perception of shift in rainfall exerts a positive and significant effect on farming households' decision to adopt both intensification and livelihood diversification as an adaptation strategy at 5% level. This means as fishing households who perceive that there have been changes in rainfall are 9.7% and 9.2% more likely to adopt intensification and livelihood diversification respectively as an adaptation strategy.

Finally, location was found to exert a negative and significant effect on the adoption of intensification as an adaptation strategy at 1%. This means that fishing households who were located in Rivers State were 13.8% more likely to adopt intensification as an adaptation strategy. It is important to note that when compared to Bayelsa State, Rivers State is more developed and has a weather station. It is possible to fishers located there has more access to climate information than their counterparts thereby making them adopt adaptation strategies.

**Table 5.** Multinomial regression results for determinants of adaptation strategies by fishing households.

| Explanatory variables | Intensification Coefficient | Livelihood diversification Coefficient |
|---|---|---|
| Age | 0.001<br>(0.030) | -0.001<br>(0.019) |
| Gender | 0.018<br>(0.529) | 0.006<br>(0.139) |
| Fishing experience | -0.002<br>(-0.039) | 0.001<br>(0.018) |
| Household size | -0.004<br>(-0.104) | -0.001<br>(-0.032) |
| Education | 0.015***<br>(0.367) | 0.009**<br>(0.196) |
| Access to credit | 0.030<br>(0.622) | 0.023<br>(0.416) |
| Social network | -0.017<br>(-0.518) | -0.028<br>(-0.700) |
| Extension | 0.034<br>(1.077) | 0.309<br>2.4239 |
| Access to climate information | -0.070**<br>(-1.664) | -0.042<br>(-0.886) |
| Household income | 2.61e-08<br>(6.83e-07) | 3.71e-08**<br>(7.38e-07) |
| Perception of shift in temperature | -0.037<br>(-0.859) | -0.058<br>(-0.980) |
| Perception of shift in rainfall | 0.097**<br>(2.346) | 0.092**<br>(1.867) |
| Location | -0.138***<br>(-2.738) | 0.003<br>(-0.099) |
| Constant | -5.5811*** | -4.5704** |
| Diagnostics | | |
| Number of observations | 252 | |
| LR(26) | 144.03 | |
| Prob > chi2 | 0.0000 | |
| Log likelihood | -106.04623 | |
| Pseudo $R^2$ | 0.4044 | |

Note: Base category: no adaptation; ***, ** and * indicate significance at 1%, 5% and 10% respectively; Location base category: Rivers; Values in parentheses are the standard errors.
Source: Field survey (2018).

Location has been found by others studies such as Mabe & Asase (2020), Ali & Erenstein (2017) to be an important factor influencing adoption of adaptation strategies.

## 5. CONCLUSION AND POLICY RECOMMENDATION

The study examined the farmers' and fishers' perceptions of the changing climate. They perceived a decrease in rainfall and an increase in temperature which is consistent with the historical meteorological trend from 1982-2018. Furthermore, the study investigated the various adaptation strategies employed by farmers and fishers to adapt to climate shocks and factors that affect the adoption of these adaptation strategies. The main adaptation strategies employed by farming households were soil and water conservation practices, crop management practices, and livelihood diversification while fishing households adopted intensification and livelihood diversification as adaptation strategies. Livelihood diversification was a common adaptation strategy for both livelihood groups. We used the MNL model to examine the factors influencing the adoption of the various adaptation strategies by both livelihood groups and the findings confirm that age, education, farm size, and being a male-headed household are among the important factors that increase the likelihood of farmers to adapt to climate shock using soil and water conservation practices whereas access to credit and social network discourages farmers from using this as an adaptation strategy. Our results further show that household size, education, and perception of changes in rainfall exert positive effects on the use of crop management as an adaptation strategy while access to climate information exerts a negative influence. We also find that farm size positively influences farmers to diversify their sources of livelihood whereas female headed households and households who do not have access to extension are more likely to adopt livelihood diversification as an adaptation strategy. On the other hand, factors such as education, household income, and perception of rainfall change positively influence the adoption of livelihood diversification as an adaptation strategy by fishing households. Furthermore, the results show that education and perception of changes in rainfall exert positive effects on the use of intensification as an adaptation strategy while fishers who do not have access to climate information and in Rivers State are more likely to use intensification.

The findings of this study have strong implications for agricultural policy formulation. The heterogeneity in adaptation strategies and determinant suggest that "one size fits all" policies will not work to adapt to climate change. Institutional factors such as extension visits, access to credit, social networks, and access to climate information for the farmers should be further investigated as such factors negatively influence the choice of climate change adaptation strategies contrary to the findings of some studies. The empirical findings of this study reinforce the need for policymakers to intensify their efforts in improving the extension service in Nigeria. As can be seen from the results only 8% and 4% of the farmers and fishers respectively had access to extension.

This would facilitate the free flow of information on climate and agricultural innovations to farmers and fishers, especially to those who cannot afford information technology devices. Again, membership in associations is another important channel for climate information acquisition that facilitates the adoption of adaptation measures. As can be seen from the study only 15% and 7% of farmers and fishers had membership in any social group. Local opinion leaders and other stakeholders should encourage the establishment of farmer and fisher-based organizations in the communities. This could facilitate efficient relay of climate information, and education on the use of climate information in the adoption of adaptation measures. Also, the limited access of the farmers (15%) and fishers (10%) to credit could be the reason why they are not adopting the crop management and livelihood diversification as an adaptation strategy. These adaptation strategies could be capital intensive, so policy makers and relevant stakeholders could help ease their liquidity constraints by providing them with affordable credit schemes. In addition, the meteorological services in the region should be improved so that they can educate and provide real-time weather information to enhance the households' understanding of climatic changes to make strategic adaptation decisions. Investing in education is critical for overall development and may thus provide a policy instrument for enhancing their perception of climate change and promoting the use of climate shock adaptation strategies and thereby reducing the vulnerability of both farmers and fishers. Finally, since household size and farm size were found to positively influence adoption, the policy implication could be the provide access to farm machinery, which will minimize labour requirements and thereby enable farming households to implement adaptation measures.

Given the increasing threat from climate change and increase in the demand for food resulting from increasing population, improving adaptation by addressing the aforementioned issues is a fundamental intervention in pursuit of reducing the vulnerability of farming and fishing households thereby improving their livelihoods. More so, since women are mainly responsible for food production in the area, as well as supply majority of the labour used in agriculture, further research could be conducted to examine how climate change might have a differential impact based on gender as well as the determinants of adaptation through gender lenses. As gender has been found to play an important role in decision-making in households. Finally, this study was based on cross-sectional data and hence might not provide a robust mechanism for establishing causality, as would have been the case with a time series or panel data. In addition, the data used in this study is not representative of the national demography. We, therefore, recommend future studies using nationally representative panel data to better test addressed the research questions posed in this study.

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**Appendix 1.** Hausman tests of IIA assumption for farmers.

| | Chi square | df | P>Chi square |
|---|---|---|---|
| 0 | -4.039 | 24 | . |
| 1 | -1.943 | 23 | . |
| 2 | 4.638 | 24 | 1.000 |
| 3 | -14.650 | 24 | . |

**Appendix 2.** Hausman tests of IIA assumption for fishermen.

| | Chi square | df | P>Chi square |
|---|---|---|---|
| No adapt | -6.131 | 13 | . |
| intensif | -0.533 | 13 | . |
| diversif | -7.049 | 13 | . |

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**ORCID**
IP: 0000-0001-6833-5155
MRL: 0000-0002-5731-767X
AM-C: 0000-0001-9247-9167
PDH: 0000-0002-9646-3223

# Organic cocoa farmer's strategies and sustainability

Ibrahim Prazeres[1,*], Maria Raquel Lucas[1], Ana Marta-Costa[2], Pedro Damião Henriques[3]

[1] *CEFAGE - Center for Advanced Studies in Management and Economics, Portugal*
[2] *CETRAD - Centre for Transdisciplinary Development Studies, Portugal*
[3] *MED - Mediterranean Institute for Agriculture, Environment and Development, Portugal*
*Corresponding author. E-mail: gibaedy@gmail.com

**Abstract.** São Tomé and Príncipe (STP) is one of the world's smallest organic cocoa exporting countries, whose product has a positive socio-cultural and economic impact. Small producers who ensure it, are associated into two cooperatives that experience several difficulties and dilemmas including climate changes and poverty. Diversification of livelihood strategies could lead to wellbeing, poverty and climate mitigation. The aim of this study was to analyse producers' perception of sustainability related to the organic cocoa production in STP and to explain the influence of different factors on their livelihood strategies (LS). An ordered probit model for disaggregation of factor categories was used for the 2021 period. The results showed that gender, age, family size, members on-farm and off-farm work and professional training courses do not influence livelihood strategies. The important variables for them are education level, perception of social class, insurances and loans and access to services.

**Keywords:** households decisions, crop diversity, dependence, ordered probit model, well-being.
**JEL Codes:** Q12, Q56, O13.

## 1. INTRODUCTION

There is an overall consensus about the sensitivity of agriculture to climate neutrality (Tol, 2018; Piedra-Bonilla *et al*., 2020) and the importance of sustainability to achieve its goals and ~~to~~ meet consumer expectations and farms' profits (Menozzi *et al*., 2015).

However, while the environmental and economic dimensions of sustainability have been theorized more robustly (Hovardas, 2021; Purvis *et al*., 2019), the social dimension, which is context-specific and inherently subjective (Boyer *et al*., 2016), has lacked comprehensive approaches, notably in rural areas (Gaviglio *et al*., 2016). According to Rasmussen *et al*. (2017), only 25% of the scientific articles dedicated to sustainability in agricultural production consider the social dimension, and the most used indicators in this

field are related to the farm labour, quality of life and well-being, and the relationship with the human community (Marta-Costa *et al*., 2022).

The lack of an approach to social sustainability in studies on developing countries, where poverty is the most serious problem, could compromise the performance of the two others pillars (Prazeres *et al*., 2022a), since the relationships among the three dimensions is generally assumed to be compatible and mutually supportive (Boström, 2012; Chopin *et al*., 2021).

There are several studies in the literature that reveal the problems and challenges faced by smallholder farmers affecting the production system. These problems come as a result of isolation, small farm size, low levels of technology, innovation and productivity due to farming systems under traditional practices (Prazeres *et al*., 2021; Díaz-Montenegro *et al*., 2018), climate changes (Piedra-Bonilla *et al*., 2020) and a failure to attract young people and ensure farm succession and/or rejuvenation (Anyidoho *et al*., 2012; Henning *et al*., 2022). Additionally, these farmers are constrained by limited financial, natural, health and educational resources, scarce governance and/or organisational support, and pressure to use land with alternative crops or activities, which are more profitable (Prazeres & Lucas, 2020; Prazeres *et al*., 2021). Additionally, they must adapt to severe crop losses due to disease and, very often, they need to consider other activities when making the choices on their livelihood strategies (Tittonell, 2014; Valbuena *et al*., 2015; Walelign, 2016; Walelign & Jiao, 2017). Thus, the sustainability social pillar makes the search for livelihoods a priority in order to reduce poverty and increase the farms' wellbeing.

In São Tomé and Principe (STP), agriculture comprises a third of the active population and cocoa activity contributes to over 90% of the national exports, standing out from other export products such as coffee, coconut, flowers, pepper and other spices. In addition to the high amount of cocoa as exported goods (Signoret, 2019) and its contribution to the GDP (21%), organic cocoa production (OCP) leads the international country image and guarantees the livelihood of many poor families, by creating jobs and developing local economies (Prazeres, 2019). Approximately three thousand and three hundred organic small producers are integrated into the existing two cooperatives (CECAB and CECAC11). There are also organic private companies with their own production, from which Satocao and Diogo Vaz are the most relevant, the latter having its own chocolate factory and shops (Prazeres, 2019).

The sustainability of OCP in STP matters considering its impact on the agro-ecological system, the social and environmental context of the producing communities, the economic viability of the activity, and the farmer wellbeing, as well as, the viability of the consumer market, which directly relates to consumer trust in the OCP and consecutive willingness to pay a premium for such (Prazeres, 2019).

This paper attempted to explore the nexus between livelihood strategies and sustainability perception, households' organic cocoa dependency, and poverty. The livelihood strategies formed the basis for categorising producers based on households' structure and crop diversification.

The paper was organised into five sections. The following section presents background information on sustainability, poverty and livelihood strategies. The third section describes the empirical strategy and econometric specification, while the fourth section exposes and discusses the findings. The final section is dedicated to the conclusions and policy and its practical implications.

## 2. BACKGROUND

Sustainable development has become a global pursuit to the agricultural sector due to increasing greenhouse gas emissions and depletion of natural resources needed for agricultural activities (Bekun *et al*., 2019; Sarkodie & Strezov, 2019; Food and Agriculture Organisation [FAO], 2014). These challenges are furthered by the social and economic pressures that arise in a globally competitive environment (Iocola *et al*., 2018; Ramos, 2019; Santos *et al*., 2019; Vasileiou & Morris, 2006; Velten *et al*., 2015), such as rising input prices, labour supply instability, relationships with the end-product market and food safety concerns, which further evidence the need to implement sustainable practices (Christ & Burritt, 2013).

Elkington (1994)'s Triple Bottom Line theory is often regarded as the most well-known and comprehensive theoretical model used in the sustainable development approach (Hayati, 2017). This theory argues that People, Planet and Profit are imperative principles of sustainability and promotes the idea that sustainable development occurs when organisations demonstrate responsibility towards environmental health, social equity and economic viability (Hayati, 2017; Iyer & Reczek, 2017).

The geographic context takes particular importance in the sustainability paradigm, for which locally configured institutional and biophysical processes shape the criteria and scope of the analyses. Therefore, livelihood strategies need to be seen in light of the extent of the resources' constraints and their availability, which

support communities in achieving livelihood objectives (Chilombo & van der Horst, 2021). For instance, the poverty evidenced in rural areas of low- and middle-income countries, that hinders individual and community capacities to meet basic needs, stands out as a multidimensional global challenge to sustainable development (Alemie *et al*., 2022). In these areas, about 90% of the people depend on agriculture for their livelihoods (FAO, 2005; IFAD, 2011; Roser, 2015; Mphande, 2016 in Alemie *et al*., 2022), making it urgent to seek strategies that promote the sustainability of agroecological systems and support improvements in the social and environmental context of producing communities (Prazeres *et al*., 2019).

The concept of sustainable livelihood appeared in the 1980s (Chambers & Conway, 1991), ~~and~~ remerged in Chilombo and Van der Horst (2021) and has become a classic paradigm for the study of household livelihoods (Kuang *et al*., 2020). It is focused on coping strategies intertwined with livelihood activities that are linked to the exploitation of land-based resources in rural communities (Kuang *et al*., 2020).

Several studies have been conducted on the livelihood strategies that affect the interaction of sustainable dimensions, specifically in the African context and the agricultural sector. Alemie *et al*. (2022) identified complex interdependencies between livelihoods and the regulatory supply and cultural ecosystem services, which create bottlenecks to effectively 'block' poverty in Ethiopia, where 85% of the population are subsistence farmers dependent on local ecosystem services.

The research by Berhanu *et al*. (2022) found that an asset-based social policy improves the well-being of poor and vulnerable subgroups and Chilombo and van der Horst (2021) define assets in terms of human, natural, physical, social and financial capital and capabilities.

The capital assets in conjunction with the activity variables and the outcomes, constitute the three closely connected components in which several studies focused on smallholder farmers are concentrated (Ellis, 2000; Winters *et al*., 2009; Nielsen *et al*., 2013; Walelign & Jiao, 2017). Empowerment and community involvement play an important role in this context (Arroyo, 2013).

The achieved livelihood strategies' outcomes increase income, multidimensional wellbeing and a more sustainable use of natural resources (Babulo *et al*., 2008).

However, no single livelihood strategy provided both optimal economic advantages and ecological sustainability (Ghazale *et al*., 2022). Even when the households' choices induced similar livelihood activities, the time or capital used on the diverse livelihood activities may be different (Walelign & Jiao, 2017).

Still in this sustainable perspective, Deng *et al*. (2020) forward three determinants of livelihood sustainability – livelihood basis, livelihood acceleration and livelihood environment linked with "starting force", "driving force" and "supporting force," respectively, which support different levels of livelihood performance and dynamic processes of livelihood sustainability.

The livelihood strategies are changing over time (Walelign *et al*., 2017) originating the livelihood transition or mobility (Zhang *et al*., 2019). According to Zhang *et al*. (2019), the assessment of the factors that affect this transition has strong implications on poverty reducing policies and achieving livelihood sustainability in the long run.

Since livelihood is composed and conditioned by many factors, including ecology, economy, society and institution (Zhao, 2017), sustainable livelihood development is affected by the combined action of many elements (Deng *et al*., 2020).

The farmers' decisions on agricultural production that are based on the livelihood assets, also support families in coping with livelihood vulnerability and risks (Fang *et al*., 2014; Liu *et al*., 2018; Jalón *et al*., 2018; and Kuang *et al*., 2020).

In order to deal with natural threats and market risks, farmers try to adjust crop diversity, water and fertiliser management as well as agricultural financial and agrotechnical support (Kuang *et al*., 2020).

## 3. METHODS

Seemingly, cocoa production connects smallholder farmers and their families or representatives in producer countries, to a global value chain and markets, driven by a strong, consistent and increasing demand for chocolate. The global chocolate market size was estimated at USD 113,16 billion in 2021 and is anticipated to grow at a compound annual growth rate (CAGR) of 3,7% from 2022 to 2030 (GVR, 2021). The main characteristics of this worldwide value chain are the asymmetric power relations with increasing control by a few (5) corporations which make the big decisions (Diaz-Montenegro *et al*., 2018). In reality, there is a great geographic distance between highly atomized producers and the consumption markets, and cocoa producers are ignorant on consumer's preferences and their choices (Prazeres, 2019). Additionally, there is price volatility and dependency, albeit no solid connection, on five big companies which control the market and the cocoa supply worldwide. Consequently, an asymmetric distribution of value occurs, with cocoa producers receiving only 5%

of the price paid by the final consumer, while marketing and industry activities seize 25% and sales of retail chocolate capture 70% of the profits (Fountain & Huetz-Adams, 2020; Squicciarini & Swinnen, 2016; Abdulsamad *et al*., 2015). This situation is responsible for several of the problems and challenges faced by producers, one of which is poverty. Livelihood strategies are responses to farmer's decisions to face these problems, which are influenced by several factors, such as crop diversification, resources allocation (Rahman, 2016), climate changes (Rahman, 2016; Mu *et al*., 2018), soil fertility, biodiversity loss, real estate pressure through land use (Prazeres, 2019), and trust on farmers' organisations and their bargaining power (Prazeres *et al*., 2021).

In STP, where agriculture comprises a third of the active population, there are two models of cocoa production: conventional with a total yield production of 2,488 tons in 2017, which is very dependent on the prices of the New York Stock Exchange, and the certified production method (total yield production of 1,065 tons in 2017) as organic or organic plus fair trade (EU, 2021). It is expected that external economic factors, such as market prices and support as well as internal factors such as physical, social, human or natural capital, could influence producer's decisions to choose cocoa or other crops. Prazeres *et al*. (2022b) identified three livelihood strategies of OCP in STP (organic cocoa mono-crop livelihood strategy, diversified livelihood strategy with two crops - organic cocoa and banana or other and, pluriactivity livelihood strategy combining organic cocoa with three or more crops). These livelihood strategies are mainly related to the allocation of capital assets and income variables. Families with a low proportion of allocated land had higher income diversification strategies and vice versa. The study also showed that understanding how cocoa producers seek different approaches, could help envisage livelihood strategies as a way of increasing income and producers' wellbeing, as well as alleviate poverty. Also, increases in livelihood can be used by producers for consumption, commercialization or conversion into livelihood assets (Zhang *et al*., 2022).

### *3.1 Statistical model*

The diversity of livelihood strategies can be compared and the effect of different categories of factor variation can be found without the problem of selection bias. Hence, the causal relationship among those factors will be controlled following general models presented in the literature (Dusen *et al*., 2005; Benin *et al*., 2004; Piedra-Bonilla *et al*., 2020), in which livelihood strategies election is affected by factors that could be gathered as social, economic and agroecological. Thus, an ordered probit model was estimated in which the variable to be studied was the livelihood strategies, measured on a scale of three points (*LS1=Mono-crop, LS2=Bi-crop, LS3=Multi-crop*). This model can be represented as follows:

$$\begin{aligned} &LS_i^* = x_i'\beta + \varepsilon_i,\ \varepsilon_i \sim \text{NID}(0,1) \\ &LS_i = 1 \text{ if } LS_i^* \leq \gamma_1 \\ &LS_i = 2 \text{ if } \gamma_1 < LS_i^* \leq \gamma_2 \\ &LS_i = 3 \text{ if } LS_i^* \geq \gamma^2 \end{aligned} \quad (1)$$

in which $LS_i$ represented the livelihood strategy $i$ and, $\gamma_1$ e $\gamma_2$ were parameters to be estimated in conjunction with $\beta$. The estimation of the model was based on the maximum probability of occurrence and the interpretation of the coefficient was done in terms of the latent variable or in terms of the effects on the respective probability. For example, $\beta_j > 0$ meant that the latent variable $LS^*_1$ increase if $x_{ij}$ increases.

Thus, the probability of *LS3* (*Multi-crop*) increased while the probability of *LS1*(*Mono-crop*) decreased. The effect on the intermediate category was however ambiguous as it $P\ (LS_i=2 \mid x_i)$ could increase or decrease.

### *3.2 Data collection*

A survey was conducted from June to December 2021 on a sample set of 810 farmers involved in the OCP in STP through cooperatives. The selection criteria were both, the cooperative proposals and the availability of the producer to cooperate with the research. Compliance with the General Data Protection Regulation was assured throughout. The participants were informed about the use of the information, their rights, and their responses were anonymized.

All of the contacted OCP producers were members of one of the two cooperatives (CECAB created in 2004, operational from 2005 and autonomous since 2012, and CECAC11 created in 2011), which represent the main interface between farmers and the chocolate industry or their representatives or signed a contract with one of the two private companies. Both cooperatives are funded by the Fund for the Development of Agriculture (IFAD) and the Project to Support Commercial Agriculture (PAPAC) and they are supported by various non-governmental organizations as well as the Center for Agricultural and Technological Research (CIAT). Each of the cooperatives brings together different associations organized by geographic zones, which receive the cocoa seed from farmers on two distinct periods (August-September

and February-March). The training of the farmers and motivation strategies to guarantee the levels and quality of organic cocoa production are carried out by the cooperatives, which also train technicians from the associations that form them and to which the producers belong, these technicians, in turn, then train the farmers. An important role is played by the so-called "sociotechnicians", who are producers with good performance in the cocoa culture and who monitor other farmers and are remunerated for this task. In reality, these socio-technicians end up replacing the role of the extension services that the state was responsible for ensuring. In addition to strictly agricultural work, the cooperatives develop other actions, such as socio-recreational activities in the communities, inviting specialists who contribute to raising awareness among farmers on various topics (domestic violence, gender equality, alcohol consumption, diseases), financing small social works in the communities and providing support to the neediest (medicines, eyeglasses, coffins). The registration of all information is done manually at the level of the associations and the computerization is done by each cooperative.

The study area included the most significant OCP districts and rural communities in STP, namely all the districts in the country, with the exception of Caué, Pagué and Santo António – districts in the Principe Island – because they were not OCP certified members of the cooperatives. As shown in Figure 1, the survey was conducted in different steps, starting with 25 preliminary qualitative interviews with 4 cooperatives representatives and other stakeholders (4 distributors and/or exporters, 2 certification bodies, 3 private companies, 5 sociotechnicians, 2 researchers, 4 government agencies) and the establishment of 10 focus groups of 20 participants (farmers), so to specifically capture the individual and collective perception of the sustainability concept and its main drivers and challenges.

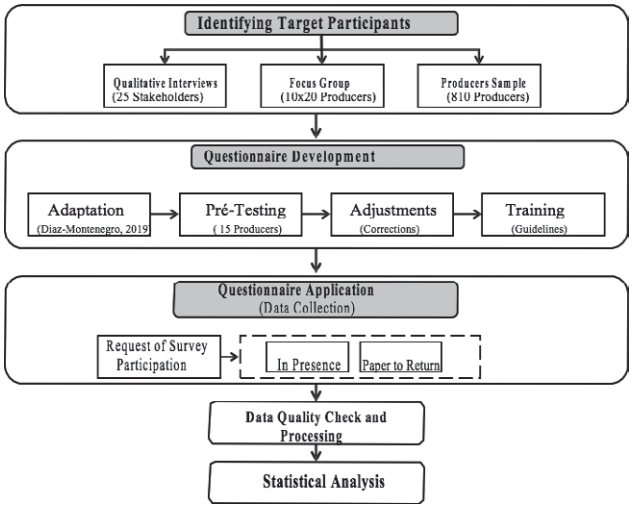


**Figure 1.** Analysis design.

Then, a questionnaire based on the livelihoods adapted from Diaz-Montenegro (2019) was applied to the organic cocoa producers, structured in three main sections. The first was dedicated to the characterisation of the household and the farm and incorporated five topics related to: Human capital (16 questions on the characterisation of the family and its relation to the farm), Natural capital (16 questions on used land and produced crops ), Physical capital (4 groups of questions about machinery, equipment and support infrastructures), Financial capital (6 questions about financing sources), and Social capital (12 questions on partnerships and cooperation and enjoyed benefits);. The second session was devoted to ~~2)~~ Risk perception and attitude and considered the probability of occurrence, their impact severity and degree of control of 19 events identified from both the literature and the country context. This group also included two questions dedicated to the management and tool preferences for risk management, comprising 12 options taken from the literature and the analysis context, and an open question where other options could be considered, namely for the future. The perceive value of joining an OCP cooperative was considered as the last section by including 12 options for assessing the benefit and cost of working with the cooperative. The reduced version of the PERVAL scale (Walsh, Shiu & Hassan, 2014) was explored in this context. This reduced version included 12 items (either observed or manifested variables or indicators, structured from ordinal variables with 7 Likert-type response categories, in which 1 meant the highest degree of disagreement and 7 the highest degree of agreement) related to four constructs (or dimensions, latent variables or factors) that underlie the abstract and multidimensional concept of Value: Functional Value, Emotional Value, Social Value and Monetary Value.

In the beginning of the questionnaire, a request of participation was highlighted alongside an explanation of the study's purpose and the guidelines to fulfil the questionnaire, so to prepare and commit the participants to the survey. Participants could fill the questionnaire in two ways: direct interview in person or through a paper questionnaire due to return and collect two days after. A total of 838 questionnaires were completed, 180 by paper and the remaining face-to-face. After the removal of 28 incomplete questionnaires, the final sample consisted of 810 respondents.

*3.3 Sample Characteristics*

Figure 2 summarises some of the statistics of surveyed smallholders, by livelihood strategies. Table A1, in appendix, presents the description of all the characteristics of the sample set, which was almost equally distributed between the two cooperatives.

Most of the participants of the sample were male, while 33% of the farmers were females and 52,2% belonged to CECAB. The livelihood strategies identified were differentiated by the number and proportion of farmers engaged in growing organic cocoa (with or without other crop combinations), and their ways of allocating resources (14,2% concerned the proportion of farmers who engaged solely in organic cocoa growing, in mono-crop livelihood strategy LS1, 63,5% were involved in a diversified livelihood strategy (LS2) with two crops (organic cocoa and banana), and, 22,2% were engaged in a multi-crop livelihood strategy (LS3), which were combined three or more crops and livelihood activities. The OCP area for the sample was on average 1,95 hectares, with the highest surface value of 12,5 hectares and the lowest value of 0,5 hectares. The average household size varied from 3,6 members in mono-crop to 4,8 in multi-crop and 4,2 in bi-crop livelihood strategies.

## 4. RESULTS AND DISCUSSION

The estimation of equation (1) using an ordered probit model yielded the results shown in Table 1. The statistical results related the dependent variable livelihood strategy (*LS1=Mono-crop, LS2=Bi-crop, LS3=Multi-crop*) with the explanatory variables . The explanatory variables were grouped in human, financial and economic, natural, physical and social capital as well as in risk perception and management and perceived value.

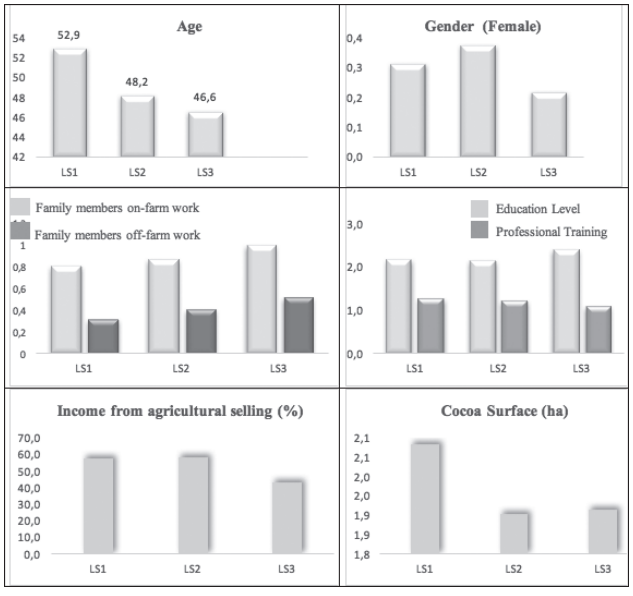


**Figure 2.** Summary of characteristics of the respondents.

Regarding human capital explanatory variables, the level of education and perception of social classes influence the livelihood strategies. Farmers of the mono-crop strategy have higher level of education than multi-crop farmers. In fact, the greater the level of education, the lower the probability of belonging to multi-crops and the greater the probability of belonging mono-crop strategy. As other studies sustained (Balogh, 2021, Reimers and Klasen, 2011; Hernández-Núñez et l., 2022), probably this is because a higher level of education leads to decisions involving greater productive efficiency, being mono-crop suitable for these choices because it is more efficient than multi-crop. In the specific STP context, Sequeira et al. (2022) concluded that improvements into production systems lead to increased family income and help to cross poverty line.

In contrast to education level, the livelihood strategy has a positive relation to social class perception. Farmers of the multi-crop strategy have a perception of belonging to higher social class than farmers of the mono-crop strategy.

This does not seem compatible with the study of Irfany et al. (2020) where social class does not influence livelihood strategies. However, the result obtained could be related to the fact that an increased social class perception allows for a belief of being under better economic conditions which is in turn beneficial to the production of organic cocoa in multi-crop (LS3).

Although not significant, there is a higher probability for mono-crop strategy to have female and younger farmers and a lower number of on-farm family members while family size, professional training courses and number of off-farm family members are higher for multi-crop livelihood strategy. Despite OCP being the main activity in the three LS, farmers also engage in different income generating activities, such as off-farm employment. The explanation for that could be related to the fact that which enables them to build better assets, increase economic sustainability and could start becoming integrated production systems (Gebru et al., 2018). Additionally, off-farm self-employment is one of the variables that significantly improves welfare but has lower probability of existing in mono-crop (Irfany et al., 2020). However, in the existing results concerning off-farm the employment, the greater the number of off-farm work members, the greater the probability of selected

**Table 1.** Results of the Probit model for livelihood strategies.

| | Coefficient | Standard error | z | p-value |
|---|---|---|---|---|
| *Human Capital* | | | | |
| Gender (F) | -0,236 | 0,184 | -1,286 | 0,198 |
| Age | -0,007 | 0,007 | -1,106 | 0,269 |
| Family size | 0,054 | 0,045 | 1,201 | 0,230 |
| Education level (EL) | -0,616 | 0,179 | -3,447 | 0,001*** |
| Number of professional training courses | 0,026 | 0,125 | 0,206 | 0,837 |
| Members on-farm work | -0,026 | 0,117 | -0,224 | 0,823 |
| Members off-farm work | 0,228 | 0,147 | 1,549 | 0,121 |
| Perception of social class (SC) | 0,674 | 0,130 | 5,182 | <0,0001**** |
| *Financial and Economic Capital* | | | | |
| Income from agricultural selling | 0,007 | 0,004 | 1,600 | 0,110 |
| Income from subsidies (human development and others) and remittances from emigrants | -0,082 | 0,360 | -0,229 | 0,819 |
| Insurances and loans (IL) | 0,929 | 0,239 | 3,891 | <0,0001**** |
| *Natural Capital* | | | | |
| Cocoa area | 0,266 | 0,212 | 1,256 | 0,209 |
| Cocoa production | 0,000 | 0,000 | -0,280 | 0,779 |
| Banana area | -0,200 | 0,195 | -1,026 | 0,305 |
| Banana production | 0,000 | 0,000 | 1,629 | 0,103 |
| *Physical Capital* | | | | |
| Access to potable water | -0,346 | 0,189 | -1,824 | 0,068* |
| Access to electricity | -0,217 | 0,561 | -0,387 | 0,699 |
| Access to harvest storage (HS) | 1,708 | 0,651 | 2,621 | 0,009*** |
| Access to transportation | -0,732 | 0,373 | -1,960 | 0,050** |
| Access to roads | -0,292 | 0,187 | -1,555 | 0,120 |
| Access to landline | 0,316 | 0,399 | 0,792 | 0,428 |
| Access to mobile phone (MF) | 1,791 | 0,396 | 4,520 | <0,0001*** |
| Access to internet | 0,470 | 0,207 | 2,272 | 0,023** |
| Access to TV and radio | 0,694 | 0,380 | 1,825 | 0,068* |
| Access to health center HC) | -2,426 | 0,548 | -4,428 | <0,0001*** |
| Access to schools | -0,445 | 0,258 | -1,723 | 0,085* |
| Access to extension services (ES) | -0,895 | 0,291 | -3,077 | 0,002*** |
| *Social Capital* | | | | |
| Belong to CECAB | -0,490 | 0,217 | -2,260 | 0,024** |
| Satisfaction with cooperatives | 0,530 | 0,248 | 2,131 | 0,033** |
| Trust level in neighbours | 0,033 | 0,125 | 0,261 | 0,794 |
| Trust level in civil organizations | 0,119 | 0,148 | 0,804 | 0,421 |
| Trust level in agricultural organizations | -0,031 | 0,101 | -0,312 | 0,755 |
| Trust level in district council | -0,797 | 0,622 | -1,280 | 0,201 |
| Trust level in local council | 1,243 | 0,614 | 2,024 | 0,043** |
| Trust level in cooperatives (TC) | -0,875 | 0,243 | -3,603 | 0,000*** |
| Trust level in government | -0,240 | 0,259 | -0,929 | 0,353 |
| *Risk Perception and Management* | | | | |
| Perception of the likelihood of risks occurring (LR) | 0,499 | 0,161 | 3,094 | 0,002*** |
| Perception of risk impact severity | -0,507 | 0,221 | -2,297 | 0,022** |
| Perception of the degree of self-control of the impact | -0,084 | 0,259 | -0,323 | 0,747 |
| Perception of the importance of risk management tools | -0,165 | 0,140 | -1,181 | 0,238 |

| | Coefficient | Standard error | z | p-value |
|---|---|---|---|---|
| *Perceived Value Scale (PERVAL)* | | | | |
| Perception of the Functional value to joining a cooperative (CFV) | -0,589 | 0,189 | -3,109 | 0,002*** |
| Perception of the Emotional Value joining a cooperative (CEV) | 0,481 | 0,180 | 2,667 | 0,008*** |
| Perception of a social value joining a cooperative (CSV) | 0,702 | 0,253 | 2,773 | 0,006*** |
| Perception of a monetary value joining a cooperative (CMV) | 0,271 | 0,243 | 1,114 | 0,265 |
| e | | | | |
| Log. of likelihood = −249.071 | | | | |
| Likelihood ratio test: Chi-square (44) = 286,245 [0,0000] | | | | |

(*), (**) and (***) significant at 10%, 5% and 1%, respectively.

LS3 (multi-crop) and the lower the probability of having LS1 (mono-crop). In the case of on-farm work, the greater the number of on-farm work members, the lower probability of selected LS3 (polyculture) and greater the probability of having LS1 (mono-crop). This is because mono-crop depend mainly on familiar work than external work. Despite external work income being a significant source of income (Bjornlund et al. 2019; Pritchard et al. 2019), it is associated with greater risks and thus, has a negative impact on the well-being of households (Nielsen et al. 2013; Bjornlund et al. 2019).

Concerning economic and financial capital, the results obtained for insurances and loans show that the probability of multi-crop livelihood strategies having insurance and loans is higher than de mono-crop strategies as well as the proportion of income from agricultural sources. In general terms, these results are compatible with those found in Irfany et al. (2020)'s study, which displayed that cocoa producers, predominantly males, depended on loans, despite the fact that only a few have accessed formal loans. To Ankrah et al. (2023), reducing loan interest rates can foster financial inclusion. In STP, loan interest rates are very high and the OCP have difficulty to access formal banks. This is very important because other significant determinants of livelihood practices were, for instance, access to formal credit for self-employment, among others. Also Kuang et al. (2020) exposed that farmers' social, financial and human assets can mitigate their livelihood risks in agricultural production, while their social, natural and physical assets have positive effects on the adoption of the strategies. However, natural and physical assets have the opposite effects in livelihood risks such as the human and financial assets have relatively weak influences in the adaptation strategies (Kuang et al., 2020).

The livelihood strategies are not related with natural capital explanatory variables, namely, area and production of cocoa and banana. These results were also in line with those found in Andres *et al.* (2016), particularly when dynamic agroforestry systems are introduced on a small scale. For the authors, through mimicking natural forests, these systems offer multiple benefits such as soil fertility enhancement, reduction of pests and disease pressure, erosion control, and revenue diversification. Very often, the diversification is induced by income-generating activities to smooth income, accumulate wealth and reduce exposure to risk (Sun et al., 2019).

Physical capital explanatory variables show in a clear way that access to potable water, transportation, health centers, schools and extension services are higher for mono-crop farmers than for multi-crop farmers while access to harvest storage, mobile phone, internet and TV and radio are higher for multi-crop farmers. It is clear that mono-crop farms have better access to state-dependent infrastructures, possibly due to the location of agricultural enterprises, while multi-crop farms have better access to services that depend on individual decisions and consumption. According Pereira et al. (2022), development programs implemented in STP to improve infrastructure and agricultural production, made a positive contribution to the well-being of rural households. Similar results found Trigueiros et al (2022) emphasizing the importance of this investments programs to improve socio-economic development and households sustainability. The perception of the importance of this public policies are more valued by male than female (Pereira et al, 2022).

Regarding risk perception and management of events that affect agricultural production and family income, the results show that livelihood strategies are different for the perception of events occurring, being this perception higher for multi-crop than for mono-crop farmers and, for severity of events, the mono-crop livelihood strategy have higher severity perception than multi-crop farmers. Thereby, adverse events are less perceived by mono-crop which value more the severity of

impact. It should mention, specifically in STP insular context where climate changes consequences are become severe, that public policies are essential tools to mitigate risk events and impacts (Gomes, 2021).

Concerning the four dimensions of the perceived value of joining a cooperative, the emotional (CEV) and the social values (CSV) of joining a cooperative, the greater the perceived value, the greater the probability of electing LS3 (multi-crop) and the lower the probability of having LS1 (mono-crop). In the case of the functional value the opposite is observed. From a production stand point, similarly to the results obtained by Moreno-Miranda et al. (2020) in–Ecuador, the price paid for product certification is debatable and not perceived as valuable.

On the linkage between livelihood strategy and the sustainability at farm level, in addition to the difference between mono-crop vs. multi-crop, it was possible to add other elements. The economic dimension of sustainability, measured by land area and number of income sources, revealed that bi-crop and multi-crop have similar areas (3,7 ha) but greater than mono-crop (2,1 ha) while the number of sources of income are higher for multi-crop (4,2) than for mono and bi-crop (2,2). Globally, multi-crop exhibited higher economic sustainability than mono and bi-crop livelihood strategies.

The social dimension of sustainability measured by the number of basic services accessed, number of professional training courses and level of trust in institutions, displayed that: mono (8,8) and bi-crop (8,4) have greater access to a higher number of basic services than multi-crop (6,7); the number of professional training courses were decreasing from mono (1,3) and bi (1,2) to multi-crop (1,1); and the level of trust in institutions was also decreasing from mono (2,6) and bi (2,5) to multi-crop (2,3). Overall the mono-crop–livelihood strategy was more robust in terms of social sustainability.

Finally, the environmental dimension of sustainability, measured by the number of crops and productivity levels, disclosed that: as expected multi-crop (3,6) has an average number of crops higher than bi-crop (2) and mono-crop (1) strategies; and Cocoa productivity for multi-crop (706 Kg/ha) is higher than bi-crop (614 Kg/ha) and mono-crop (479 Kg/ha) while banana productivity for multi-crop (918 Kg/ha) is higher than bi-crop (435 Kg/ha). Thus, the multi-crop livelihood strategy is; more environmentally sustainable than mono and bi-crop livelihood strategies.

As a whole multi-crop is the most sustainable livelihood system. There is acceptance that certified OCP have a positive sustainability effect (Blockeel et al, 2023) as well as crop diversity, as a result of increasing sources of food and income, reducing the risk of adverse events and their impact and having a positive effect on biodiversity.

## 5. CONCLUSIONS

Organic cocoa production is one of the most valued crops in STP and world-wide. The country follows ancient ancestral-style production practices, in which most of the production is in the hands of small-scale producers primarily associated with two cooperatives, which face significant obstacles regarding their sustainability.

Small scale cocoa production in STP is organized in different livelihood strategies, mono, bi e multi-crop that have similarities and differences among them and represent distinctive production systems. These three strategies have been developed as means of survival of rural households, with dependency of organic cocoa production and, in many cases, incomes still below the poverty line. This is due to the low level of production obtained, which does not allow a better position in the market, and the poor access to technical support.

Rural cocoa households have been sustained by cocoa cooperatives governance and sociotechicians' support. Cooperative goals are toward inducing and advising farmers to avoid mono-crop in order to achieve greater (bio)diversity and ecosystem services, wellbeing and economic access. These provide enhanced levels of sustainability, climate neutrality transition and market shock prevention which are expected to increase in frequency and intensity.

This research shows that globally, multi-crop livelihood strategy have the highest economic sustainability, mono-crop livelihood system was more robust in terms of social sustainability and multi-crop livelihood strategy was the most environmentally sustainable. Thus, as a whole, the multi-crop livelihood strategy is the most sustainable livelihood system.

The bi-crop and multi-crop livelihood strategies, have the potential to offset environmental and economic risks and consequently improve sustainability and wellbeing. Such pathway is relevant for a country like STP which depends economically on its OCP in order to maximize short-term productivity and profitability. Nonetheless, cocoa mono-crop has been associated with soil erosion and degradation, biodiversity loss, as well as increased susceptibility to climate change impacts, pests and diseases.

The multi-crop livelihood system is the more resilient strategy, because it holds diversified sources of

income and seems more realistic in terms of management, strategies and in the face of risks. Nonetheless, it is less autonomous because it further depends on outside linkages (e.g. off farm labour and cooperatives support).

Mono-crop farmers are more autonomous because they hold higher levels of education and experience, as well as greater access to technical support, therefore, in the absence of risk events, they can be more successful. On the other hand, in risk events, they suffer greater consequences, thus, they have a better grasp of the impact of events when dealing with severe risks. That is, when the risks are low, mono-crops respond well, when the risks are higher, a multi-crop approach may be more suitable.

The results of this study devise crucial policy implications for designing adaptations to organic cocoa national policy, which would involve, for example, better technical assistance, credit, and investment in the development of diversified practices and cocoa plants' selection, which respond to poverty and climate variability. They can be used to recommend governance measures to lead livelihood strategies to a higher sustainability level in all dimensions and the adoption of climate change adaptations. For instance, the roles of research, knowledge transfers and extension programs in promoting more resilient and sustainable livelihood strategies are vital to promulgating best practices and the ecosystems' preservation. Hence, it is crucial to progress in research, development and innovation (R&D&I) and gather the essential knowledge to be able to move current OCP livelihood strategies to new cleaner circular business models.

Finally, in terms of practical implications, the research demonstrated several factors with potential to improve organic cocoa livelihoods, but also obstacles, especially in terms of formal credit access, infrastructures scarcity, actions to deal with risk events and trust in institutions and governance practices. These may deter poorer smallholders from diversifying their income sources and improve their social wellbeing. The engagement of producers in social programs and policies that facilitate access to formal finance, could encourage small business livelihood strategies and improve transparency and trust in organic cocoa-dependent communities.

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## APPENDIX

**Table A1.** Variables definition and descriptive statistics.

| Variable | Description | Total sample | | | | | LS1 Mono-crop | | LS2 Bi-crop | | LS3 Multi-crop | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Obs. | Mean | Standard Deviation | Min | Max | Mean | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation |
| Crops | Number of crops | 809 | 2,220 | 0,922 | 1,0 | 7,0 | 1,000 | 0,000 | 2,000 | 0,000 | 3,628 | 0,865 |
| Feminine gender | 0=male; 1= Female | 809 | 0,330 | 0,471 | 0,0 | 1,0 | 0,313 | 0,466 | 0,374 | 0,484 | 0,217 | 0,413 |
| Age | Age of farmers | 809 | 48,477 | 12,291 | 15,0 | 88,0 | 52,896 | 11,643 | 48,156 | 12,042 | 46,572 | 12,786 |
| Family size | Number of male and female members | 810 | 4,231 | 1,962 | 1,0 | 12,0 | 3,643 | 1,893 | 4,156 | 1,896 | 4,828 | 2,049 |
| Education level | 1=no studies; 2=Primary; 3=secondary; 4= Graduate | 764 | 2,205 | 0,492 | 1,0 | 4,0 | 2,165 | 0,396 | 2,148 | 0,462 | 2,401 | 0,581 |
| Number of professional training courses | Number of training courses enrolled | 810 | 1,183 | 0,720 | 0,0 | 6,0 | 1,252 | 0,590 | 1,202 | 0,632 | 1,083 | 0,980 |
| Number of members on-farm work | Family members with farm work | 810 | 0,886 | 0,739 | 0,0 | 3,0 | 0,800 | 0,829 | 0,868 | 0,713 | 0,994 | 0,744 |
| Number of members off-farm work | Family members with off-farm work | 810 | 0,412 | 0,538 | 0,0 | 3,0 | 0,313 | 0,466 | 0,399 | 0,506 | 0,511 | 0,647 |
| Perception of social class | 1=very low; 2=low; 3=low average; 4=average; 5=high average; 6=high | 810 | 2,816 | 0,731 | 1,0 | 6,0 | 2,739 | 0,869 | 2,837 | 0,603 | 2,806 | 0,940 |
| Income from agricultural selling | Percentage of income from agricultural selling | 810 | 54,640 | 25,585 | 25,0 | 100,0 | 57,548 | 18,366 | 58,035 | 25,440 | 43,089 | 26,690 |
| Income from subsidies (human development and others) and remittances from emigrants | 0=do not receive subsidies; 1=receive subsidies | 810 | 0,037 | 0,189 | 0,0 | 1,0 | 0,000 | 0,000 | 0,023 | 0,151 | 0,100 | 0,301 |
| Insurances and loans | 0=do not have insurance and loans; 1=have insurance and loans | 810 | 0,072 | 0,258 | 0,0 | 1,0 | 0,052 | 0,223 | 0,054 | 0,227 | 0,133 | 0,341 |
| Cacao area | Hectares | 810 | 1,931 | 0,812 | 0,5 | 12,5 | 2,084 | 0,422 | 1,903 | 0,874 | 1,915 | 0,807 |
| Cacao total production | Kilos | 782 | 1110 | 763,069 | 1,5 | 9600 | 983 | 877,040 | 1066 | 629,593 | 1341 | 992,544 |
| Banana area | Hectares | 662 | 1,920 | 0,839 | 0,5 | 12,5 | 1,625 | 0,250 | 1,912 | 0,836 | 1,947 | 0,858 |
| Banana total production | Kilos | 658 | 939 | 1222,185 | 20,0 | 12000 | 2000 | 0,000 | 725 | 932,667 | 1520 | 1676,375 |
| Access to potable water | 0=without access; 1=with access | 786 | 0,355 | 0,479 | 0,0 | 1,0 | 0,200 | 0,402 | 0,389 | 0,488 | 0,360 | 0,482 |
| Access to electricity | 0=without access; 1=with access | 786 | 0,983 | 0,128 | 0,0 | 1,0 | 1,000 | 0,000 | 0,982 | 0,132 | 0,975 | 0,156 |
| Access to harvest storage | 0=without access; 1=with access | 785 | 0,760 | 0,427 | 0,0 | 1,0 | 0,939 | 0,240 | 0,821 | 0,384 | 0,438 | 0,498 |
| Access to transportation | 0=without access; 1=with access | 785 | 0,753 | 0,432 | 0,0 | 1,0 | 0,939 | 0,240 | 0,813 | 0,390 | 0,425 | 0,496 |
| Access to roads | 0=without access; 1=with access | 785 | 0,768 | 0,422 | 0,0 | 1,0 | 0,730 | 0,446 | 0,821 | 0,384 | 0,625 | 0,486 |
| Access to landline | 0=without access; 1=with access | 785 | 0,028 | 0,165 | 0,0 | 1,0 | 0,035 | 0,184 | 0,022 | 0,146 | 0,044 | 0,205 |
| Access to mobile phone | 0=without access; 1=with access | 785 | 0,930 | 0,256 | 0,0 | 1,0 | 0,983 | 0,131 | 0,902 | 0,298 | 0,981 | 0,136 |
| Access to internet | 0=without access; 1=with access | 785 | 0,173 | 0,379 | 0,0 | 1,0 | 0,130 | 0,338 | 0,145 | 0,353 | 0,294 | 0,457 |
| Access to TV and radio | 0=without access; 1=with access | 785 | 0,968 | 0,215 | 0,0 | 1,0 | 1,000 | 0,000 | 0,951 | 0,265 | 1,000 | 0,000 |

| Variable | Description | Total sample | | | | | LS1 Mono-crop | | LS2 Bi-crop | | LS3 Multi-crop | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Obs. | Mean | Standard Deviation | Min | Max | Mean | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation |
| Access to health centre | 0=without access; 1=with access | 785 | 0,764 | 0,425 | 0,0 | 1,0 | 0,965 | 0,184 | 0,821 | 0,384 | 0,438 | 0,498 |
| Access to schools | 0=without access; 1=with access | 784 | 0,902 | 0,298 | 0,0 | 1,0 | 0,991 | 0,093 | 0,910 | 0,287 | 0,811 | 0,392 |
| Access to extension services | 0=without access; 1=with access | 784 | 0,711 | 0,453 | 0,0 | 1,0 | 0,904 | 0,295 | 0,786 | 0,411 | 0,333 | 0,473 |
| Belong to CECAB | 0=do not belong to CECAB; 1= belong to CECAB | 810 | 0,522 | 0,500 | 0,0 | 1,0 | 0,800 | 0,402 | 0,589 | 0,492 | 0,150 | 0,358 |
| Satisfaction with cooperatives | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 754 | 4,507 | 0,663 | 2,0 | 5,0 | 4,774 | 0,578 | 4,496 | 0,606 | 4,331 | 0,831 |
| Trust level in neighbours | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 799 | 3,564 | 0,905 | 1,0 | 5,0 | 3,887 | 0,542 | 3,670 | 0,821 | 3,040 | 1,104 |
| Trust level in civil organizations | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 754 | 3,935 | 0,590 | 1,0 | 5,0 | 3,965 | 0,476 | 3,974 | 0,498 | 3,775 | 0,878 |
| Trust level in agricultural organizations | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 799 | 2,355 | 0,920 | 1,0 | 5,0 | 2,070 | 0,558 | 2,470 | 0,934 | 2,207 | 1,010 |
| Trust level in district council | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 799 | 1,070 | 0,388 | 1,0 | 5,0 | 1,070 | 0,413 | 1,041 | 0,314 | 1,155 | 0,531 |
| Trust level in local council | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 799 | 1,064 | 0,350 | 1,0 | 5,0 | 1,052 | 0,292 | 1,035 | 0,305 | 1,155 | 0,474 |
| Trust level in cooperatives | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 754 | 4,521 | 0,682 | 1,0 | 5,0 | 4,861 | 0,560 | 4,518 | 0,629 | 4,254 | 0,820 |
| Trust level in government | 1=none; 2=just a little; 3=indifferent; 4=High; 5=very high | 799 | 0,431 | 0,220 | 1,0 | 5,0 | 1,087 | 0,431 | 1,026 | 0,220 | 1,109 | 0,532 |
| Perception of the likelihood of risks occurring | 1=low probability … 7=high probability | 809 | 2,599 | 0,804 | 1,3 | 5,8 | 2,252 | 0,454 | 2,471 | 0,725 | 3,185 | 0,900 |
| Perception of risk impact severity | 1=low impact … 7=high impact | 809 | 4,729 | 0,615 | 1,8 | 6,3 | 4,522 | 0,520 | 4,733 | 0,503 | 4,852 | 0,875 |
| Perception of the degree of self-control of the impact | 1=low control … 7=high control | 809 | 4,004 | 0,326 | 1,6 | 5,1 | 3,975 | 0,391 | 4,024 | 0,255 | 3,965 | 0,440 |
| Perception of the importance of risk management tools | 1=very inadequate… 7=very adequate | 809 | 4,918 | 0,524 | 1,5 | 7,0 | 4,971 | 2,917 | 4,958 | 1,500 | 4,771 | 1,750 |
| Perception of joining a cooperative - functional value | 1=strongly disagree…7=totally agree | 809 | 5,705 | 0,547 | 3,3 | 7,0 | 5,835 | 0,310 | 5,717 | 0,535 | 5,585 | 0,667 |
| Perception of joining a cooperative - emotional value | 1=strongly disagree…7=totally agree | 809 | 5,848 | 0,647 | 2,3 | 7,0 | 6,035 | 0,281 | 5,867 | 0,582 | 5,674 | 0,904 |
| Perception of joining a cooperative - social value | 1=strongly disagree…7=totally agree | 809 | 5,952 | 0,421 | 3,3 | 7,0 | 6,026 | 0,283 | 5,941 | 0,402 | 5,935 | 0,530 |
| Perception of joining a cooperative - monetary value | 1=strongly disagree…7=totally agree | 809 | 5,949 | 0,405 | 3,7 | 7,0 | 5,977 | 0,210 | 5,969 | 0,344 | 5,874 | 0,604 |

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**ORCID**
LD: 0000-0002-3646-534X
KM: 0000-0002-2962-7646
AK: 0000-0001-9095-4905
SMM: 0000-0002-0976-1880
UG: 0000-0002-9073-6294

# A complex web of interactions: Personality traits and aspirations in the context of smallholder agriculture

Luzia Deißler[1,*], Kai Mausch[2], Alice Karanja[3], Stepha McMullin[3], Ulrike Grote[1]

[1] *Leibniz University Hannover, Institute for Environmental Economics and World Trade, Germany*
[2] *Center for International Forestry Research (CIFOR)-World Agroforestry (ICRAF), Nairobi, Kenya and Bonn, Germany*
[3] *Center for International Forestry Research (CIFOR)-World Agroforestry (ICRAF), Nairobi, Kenya*
*Corresponding author. E-mail: deissler@iuw.uni-hannover.de

**Abstract.** Some recent research began to shift the focus of development efforts away from income and yield to more diverse concepts that consider people's intrinsic drivers and values, such as aspirations and personality traits. We aim to contribute to the literature by exploring the connections between intrinsic drivers. Hence, we analyze if and how the formation of aspirations relates to personality traits against the background of different socio-economic household characteristics. This research will help us provide practical insights for the successful design of development projects specifically tailored to the unique needs and aspirations of individuals and households. Our analyses are based on a primary data set of 272 smallholder farming households in rural and peri-urban Kenya. Structural Equation Modeling (SEM) results show a significant positive correlation of personality traits with aspirations (openness; extraversion; conscientiousness), indicating that personality structures indeed correlate with the formation of aspirations in a rural, agricultural context. Furthermore, we show that household and respondent characteristics are associated with differences in education, income, and social aspirations. Considering intrinsic factors for the prediction of human behavior has the potential to increase the efficiency of agricultural development projects and policies. We conclude that a contextualized understanding of aspirations can provide useful insights for development practice aiming to support smallholder farmers' livelihoods.

**Keywords:** Big Five, aspirations, smallholder agriculture, rural livelihoods, Kenya.
**JEL codes:** D91, Q12.

## 1. INTRODUCTION

The agricultural sector in sub-Saharan Africa (SSA) faces numerous present and urgent challenges that affect current farming systems (FAO, 2018; Horton et al., 2017; Rockström et al., 2009) and require sustainable solutions.

Traditional development efforts often focus on increasing income (Frediani, 2010). However, these approaches do not always lead to success as the well-being of individuals and communities is defined differently among different contexts. Income is not a goal in itself for sustaining the needs of individuals and their families' basic primary needs, but rather the use of it (Nathan, 2005). Instead of solely focusing on tangible resources or other traditional welfare measures, assessing people's values and life goals to understand what drives and motivates them can provide practical insights for development research, projects and policies.

Farmers' decisions on land use and sustainable practices play an important role within the current global debate on climate change and sustainability (Giampietri et al., 2020; Gios et al., 2022; Menozzi et al., 2015). Moreover, psychosocial constructs are frequently being referred to for the evaluation of farmers behavior and decision-making regarding development projects and policies (Chipfupa & Wale, 2018; Giampietri et al., 2020; Mekonnen & Gerber, 2017; Menozzi et al., 2015). Recently, aspirations have received more attention as an approach to gain nuanced insights into people's life goals (Bernard & Taffesse, 2014; Horton et al., 2017), and their subsequent decision-making. Since aspirations are theorized to be highly relevant for understanding the complex livelihood decisions of farmers, they can help align project or policy implementation with farmers' individual life goals in order to improve adoption and success. Aspirations can be viewed as drivers of a particular behavior that is supposed to lead to well-being in the future (Bernard & Taffesse, 2014). They can therefore provide additional details to broaden the understanding of decision-making processes and human behavior.

Amongst various external factors that influence the formation of aspirations (Ajzen, 1991; Bernard & Taffesse, 2014; Mausch et al., 2021; Ray, 2006), an important aspect under consideration is the impact of personality traits in this process (Roberts & Robins, 2000; Visser & Pozzebon, 2013). Personality traits were found to have significant influence on aspirations and life goals. However, this has so far only been investigated in studies in higher education settings in the global North, for example in Sweden with regard to individuals' business perceptions (Hansson & Sok, 2021). Furthermore, their impacts on decision-making processes have also only been examined in similar settings (Buelow & Cayton, 2020; Bühler et al., 2020; Zhao & Seibert, 2006) using artificial experimental designs (Byrne et al., 2015). The correlation of aspirations with decision-making behavior in the context of countries of the global South or agricultural settings, however, has not been investigated yet. However, there are emerging studies which have found differences in the influence of personality and aspirations across different economic decisions (Knapp et al., 2021), indicating the importance of context-specific analyses.

The objective of this research is the investigation of connections between the formation of aspirations and personality traits, and to evaluate the impact of socio-economic household and individual characteristics on these mechanisms. We aim to contribute to the literature on intrinsic drivers of decision-making, particularly in the context of agricultural settings in the global South. Towards this aim, we use econometric analyses of primary data of smallholder farming households from rural and peri-urban Kenya.

## 2. THEORETICAL AND EMPIRICAL APPROACH

### *2.1 Aspirations*

Smallholder farmers face continuous and often urgent challenges (i.a. increasing pressure on food production systems, extreme weather events, land degradation). Changes in livelihood strategies are not uncommon and contribute to risk management and increasing living standards (Ellis & Freeman, 2004). The frequently used sustainable livelihoods framework suggests numerous aspects that influence livelihood choices and strategies (Scoones, 1998). However, decisions and choices are not always the result of purely rational behavior (World Bank, 2007). Hence, not all decisions can be evaluated using standard indicators. Besides the typically considered factors such as those in the livelihood framework, intrinsic factors have recently gained attention in explaining decision-making (Mausch et al., 2018). In the pursuit of strategies and goals, it is not only 'hard' external factors that determine the outcome, but also the intrinsic drivers that shape people's goals and actions (Ajzen, 1991; Verkaart et al., 2018) as well as the effort they exert (Lybbert & Wydick, 2018). Thus, in the development context, many studies highlight the need to address aspirations and desires of farming households in the global South (Chipfupa & Wale, 2018; Lybbert & Wydick, 2018; Mausch et al., 2018; Mekonnen & Gerber, 2017; Roberts & Robins, 2000).

Aspirations can be interpreted as visions for the future and include diverse, individually defined, aspects and dimensions of well-being (Bernard & Taffesse, 2014). In the broader sense, aspirations are determined and shaped by other intrinsic factors, such as mindset, personal interests and skills (Mausch et al., 2018; Roberts & Robins, 2000), beliefs about the environment (Dolan

et al., 2012), and extrinsic factors such as farmer characteristics, household factors, access to resources, social or political conditions (Mausch et al., 2018; Mekonnen & Gerber, 2017), as well as community peers (Chipfupa & Wale, 2018). These influences affect aspirations indirectly by shaping the aspirations window, within which individual aspirations are formed. The aspiration window is a space of imaginable goals (Mausch et al., 2021; Ray, 2006). Bennike et al. (2020) stress the importance of imaginative horizons for the formation of the aspiration window. Those are affected by real and perceived limitations of specific outcomes in addition to the influence of social dynamics emerging from communities and general surroundings.

Finally, the gap between a desired level and the current status of a specific welfare dimension has been defined as the aspiration gap which, to some degree, determines a person's level of effort. Ray (2006) argues that the aspiration gap can lead to investments in the future to achieve the aspired level. If the gap is too small, it can limit motivation and investment, and progress is bound to be slower than optimal (Janzen et al., 2017). Neither should the gap be too wide, as this could induce frustration and stagnation (Janzen et al., 2017; Ray, 2006).

Cognizant of this complex web of interactions that influence aspirations and subsequent choices and actions we conclude that aspirations shape decisions and the effort put in livelihood choices and thereby, are quite important for the agricultural development context.

### *2.2 Theoretical framework*

Various theories of human behavior focus on the influence of numerous intercorrelated intrinsic and extrinsic factors on choices and decisions (Ajzen, 1991; Lybbert & Wydick, 2018; Ray, 2006; Sen, 1999). However, as stated by Ajzen (1991), a critical factor for someone's actual behavior is one's intention to act in a specific way. The 'Theory of Planned Behavior' provides a widely used model for explaining people's behavior (Ajzen, 1991). Behavior, or decision making, is influenced by different factors. Firstly, perceived behavioral control, which describes the perceived power and opportunity for someone to make a particular decision and take a corresponding action (Ajzen, 1991; Lybbert & Wydick, 2018). Secondly, subjective norms and attitudes, including societal structures and opinions on a particular topic, shape decisions. These aspects have a combined impact on an individual's intention to make a specific choice or whether to take or not to take a specific action to achieve well-being. It is notable that the drivers of intention described by Ajzen (1991) are similar to the

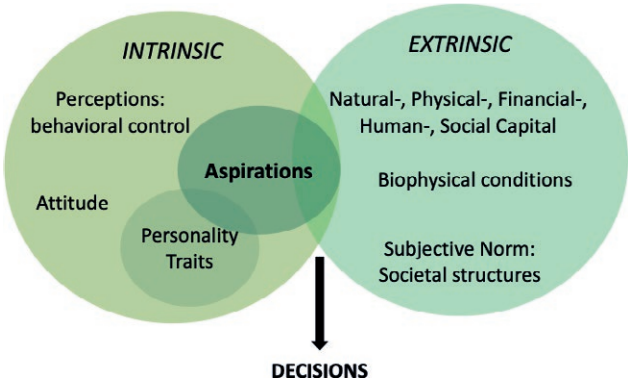


**Figure 1.** Conceptual framework of the formation of aspirations (Ajzen, 1991; Bernard & Taffesse, 2014; Mausch et al., 2021).

factors shaping aspirations. Moreover, aspirations can be highly relevant for understanding the individual valuation of well-being, hence, the way people decide to use their resources. Since aspirations are significantly associated with livelihood choices (Ajzen, 1991; Mausch et al., 2018; Verkaart et al., 2018), they should be included in a framework describing individual decision-making. To shed light on the specific formation of choices and the interlinkage between extrinsic and intrinsic factors and their impact on well-being, aspirations and their role in livelihood strategies and decision-making play an important role.

The first step in understanding that process is refining the understanding of aspirations and their formation. Figure 1 shows our conceptual framework for the formation of aspirations in the context of smallholder agriculture. External factors, such as resources and subjective norms provide the frame of the theoretically feasible, whereas individual preferences and personality traits account for the intrinsic attributes. Both parts influence the aspiration window and subsequent formation of aspirations.

Additionally, besides the stated factors, there is evidence for a correlation between personality traits, major life goals and aspirations (Roberts & Robins, 2000; Visser & Pozzebon, 2013). It was shown that personality traits can be directly linked to specific economic decisions (Zhao & Seibert, 2006). Gutman and Akerman (2008) suggest that individual self-perception influences aspirations, indicating a relationship between personality traits and aspirations. Yet, most findings are based on samples within higher education settings in the global North. Thus, examining the transferability of these findings to agricultural households' decision-making could provide useful insights for the application in development projects. Exploring the correlation of personality

**Table 1.** Description of the Big Five (Costa & McCrae, 2017; Xu, 2020).

| Personality traits – Big Five | |
|---|---|
| Openness | open to new information; fantasy, feelings, actions, ideas, values |
| Conscientiousness | efficient, hardworking, organized; competence, dutifulness, achievement striving, self-discipline |
| Extraversion | outgoing and social; assertiveness, activity, excitement seeking, positive emotions |
| Agreeableness | kind, empathic, cooperative; straightforwardness, altruism, compliance, modesty |
| Neuroticism | anxiety, further negative emotions (e.g. depression, vulnerability) |

traits with aspirations is a first step towards this direction. Most studies rely on the Five-Factor Model or Big Five (Table 1), which is a commonly used concept for measuring personality traits (i.a. Buelow and Cayton, 2020; Bühler et al., 2020; Byrne et al., 2015; Nishimura and Suzuki, 2016; Xu, 2020). It includes aspects that capture a person's extraversion, agreeableness, conscientiousness, neuroticism, and openness (McCrae & John, 1992). Although these traits are more commonly used in the global North, it was found that it can also be applied in studies in the global South such as Thailand and Vietnam (Bühler et al., 2019, 2020).

### *2.3 Data*

Our analysis uses primary data collected as part of the Fruit Tree Portfolio (FTP) project carried out by World Agroforestry (McMullin et al., 2019). The project aimed to close seasonal dietary gaps in rural households by providing location-specific portfolios of a diversity of selected fruit trees and annual crops (McMullin et al., 2019). The data for this study was collected in 2021 across three Kenyan counties (Laikipia, Tharaka Nithi, Kitui) covering semi-arid agro-ecological zones. The total sample consisted of 272 households. The survey included general socio-economic characteristics, personality traits and aspirations. Socio-economic household characteristics captured the extrinsic factors stated in the theoretical framework (Chapter 2.2), covering financial-, physical-, social- and human capital (Table 2). Data on personality traits (Big Five) were collected following the German Socio-Economic Panel (SOEP) (Caliendo et al., 2011).[1] Aspirations were captured following the methodology of (Bernard & Taffesse, 2014).[2] The use of Likert scales to capture current and aspirational levels of income, education, and social status worked quite well in the smallholder context based on the quality of

**Table 2.** Description of the variables used in the correlation analyses.

| Variable | Explanation |
|---|---|
| Aspirations | Level of education, income and social status wanted to achieve |
| *Household characteristics* | |
| total income | Total monthly HH income (KW) |
| access to credit | Access to credit services |
| farm size | Size of the entire farm (acres) |
| number of extension visits | Number of extension visits during the last 12 months |
| shocks | Number of shocks experienced in the last three years (climatic, biological, economic, other) |
| HH size | Number of household nucleus members |
| gender HH | Gender of the HH head, binary (0=female, 1=male) |
| education HH head | Highest level of education achieved by the household's head |
| food security | Number of months without enough food during the last year (using Months of Adequate Household Food Provisioning – MAHFP) |
| *Respondent characteristics* | |
| gender | Gender of the respondent, binary (0=female, 1=male) |
| age | Age of the respondent (in years) |
| education | Highest level of education achieved by the respondent |
| membership | Number of different groups/ organizations the respondent is a member of |
| travel | Number of travels outside of one's own village for one month |
| media use per week | Number of times media was used during one week (television, radio, internet) |

[1] Table A (Appendix) shows the two questions per personality trait asked within the questionnaire, following a five point Likert scale. The Big Five traits are then computed by adding up the Likert scale points and calculating the average score per trait.

[2] The questionnaire included two questions for capturing aspirations per each welfare dimension (income, education, social status), followed by one question regarding the importance of each dimension (Table A, Appendix). First, respondents are asked to establish a scale of 1-10, 1 representing the person in their community with the lowest score and 10 representing the person with the highest score. On this scale, respondents rank themselves according to their current status. Second, respondents state the status they would like to achieve in the future (can be higher than 10). Finally, respondents rank the welfare dimensions according to their personal importance.

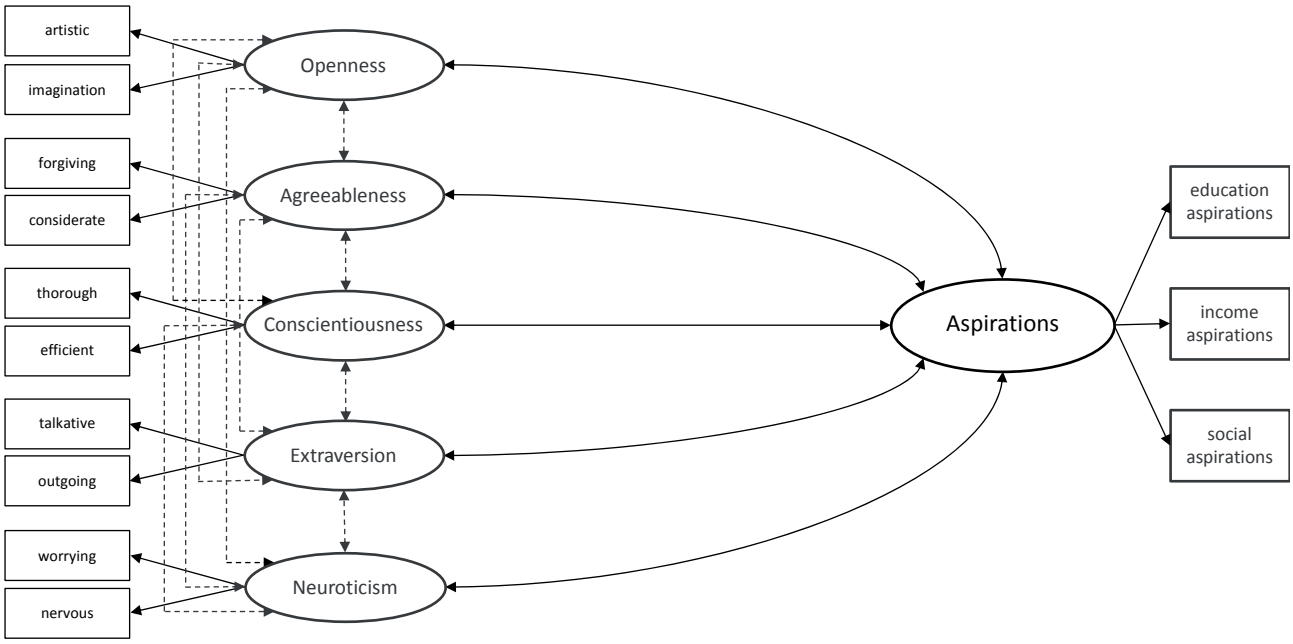


**Figure 2.** Model specification of the SEM measurement and structural model.

data collected. This was enabled by thorough enumerator training, which capacitated the team to facilitate a comprehensive understanding of the scales by the smallholder farming respondents.

The general sample characteristics are presented in Table B (Appendix). Of all households, 21% are headed by women, with the highest proportion of female-headed households in Laikipia at 39%. The main source of household income is wages (43%), while the usual occupation of the household head is casual labor, and farming for the spouse. While households located in Kitui farm the biggest areas (2.35 acres), their average monthly household income is lowest with 5,648 Kenyan Shilling[3]. General aspirations are lowest in Kitui as well, and highest in in Tharaka Nithi, mainly based on comparatively high educational aspirations.

### *2.4 Methodology*

Previous studies used correlation models to examine the relationship between the Big Five and aspirations (Buelow & Cayton, 2020; Byrne et al., 2015; Roberts & Robins, 2000; Xu, 2020). To detangle the complex relationships and to account for the intangibility of the variables we performed descriptive analyses and Structural Equation Modelling (SEM) in STATA 14.

SEM allows us to treat personality traits and aspirations as latent variables when analyzing their relationship. Thus, SEM takes into account that these variables cannot be observed directly, which can lead to measurement errors. SEM compiles these latent variables according to their observed indicator variables (Bollen & Noble, 2011; Fan et al., 2016; Gallagher & Brown, 2013). It consists of two parts, the measurement model that contains the measurement of the latent variables (constructs) based on their indicators (items), and the structural model that describes the relationship between the latent variables (Hair et al., 2017). Each personality trait ($\xi_a$) consists of two respective indicators ($x_i$, $x_j$), whereas the aspirations construct consists of three indicators ($x_i$, $x_j$, $x_k$). We specified the SEM model according to the literature and proxy general aspirations by education ($x_i$), income ($x_j$) and social aspirations ($x_k$) (Bernard & Taffesse, 2014), while each personality trait ($\xi_a$) consists of two respective indicators ($x_i$, $x_j$), as described in the data section (Caliendo et al., 2011) (Figure 2).

Information on the respective questions is shown in the Appendix, Table A. We used the aspirations gap as the indicator for aspirations, based on the assumption by Ray (2006) that the aspirations gap is the immediate driver of actions and decisions. We further hypothesized that the personality traits are intercorrelated with each other (indicated by the dotted line arrows).

The first step is the confirmatory factor analysis (CFA) as part of the measurement model (shown exem-

[3] 51.51 US Dollar based on exchange rate for time of data collection (2021) derived from World Bank 2022 (109.64).

plary for a latent construct with two items):

$$x_i=\lambda_{ia}\xi_a+\delta_i, \quad \text{Eq. 1}$$
$$x_j=\lambda_{ja}\xi_a+\delta_j \quad \text{Eq. 2}$$

With $\xi_1$ as the latent variable or factor, $x_i/x_j$ as the observed variable or item, $\lambda_i/\lambda_j$ is the factor loading that represents the respective difference in the item per one unit change in the factor and $\delta_i/\delta_j$ as the respective error terms of the items (Bollen & Noble, 2011). In a second step, SEM calculates the covariance between the latent variables (Bollen & Noble, 2011; Jeon, 2015), representing their respective intercorrelation. The estimated coefficients provide information on the correlation of our variables of interest.

To find and confirm external determinants of aspirations for contextualizing the formation of aspirations, we analyzed differences in variables of interest (Table 2) to examine the relationship between factors derived from previous literature and aspirations. The variables include socio-economic household characteristics such as income, access to credit, farm size, extension visits, shocks, food security and household head characteristics. Further, we included variables regarding the respondent and account for gender, age, education, memberships in groups or organizations, travel frequency and media use. For the aspiration measure, we normalized each dimension (income, education and social status) and computed an aggregate index (Bernard & Taffesse, 2014). The aggregated index of the aspirations gap allows an assessment of the overall ambitions, or drive, towards achieving more in life (Bernard & Taffesse, 2014; Ray, 2006). By using the following equation (3), the values for each dimension were normalized to make them comparable across communities and dimensions (Bernard & Taffesse, 2014; LaRue et al., 2021):

$$A_i = \sum k \left(\frac{a_i^k-\mu^k}{\sigma^k}\right) * W_i^k \quad \text{Eq. 3}$$

With $k$ as the respective dimension, $a_i^k$ as the value for the aspirations regarding dimension $k$ for individual $i$, $\sigma_k$ and $\mu_k$ as the standard deviation and the community sample mean of the values for the aspirations and $W_i^k$ as the specific weight (ranking) the respondents assigned to the respective dimension. However, we did not only use the aspiration index (Bernard & Taffesse, 2014), but also looked at income, educational and social aspirations separately (LaRue et al., 2021). This allowed us to identify the importance that is placed on each dimension and shows what welfare aspects might be more important than others. We conducted Welch's T-tests to identify significant differences between those variables regarding high or low aspirations. Aspirations were classified high or low if the values are above or below average:

$$\text{Low/high: } A_{index}<0.04 \,/\, A_{index}\geq 0.04 \quad \text{Eq. 4}$$
$$A_{education}\leq 0.01 \,/\, A_{education}>0.01 \quad \text{Eq. 5}$$
$$A_{income}\leq 0.01 \,/\, A_{income}>0.01 \quad \text{Eq. 6}$$
$$A_{social}\leq 0.01 \,/\, A_{social}>0.01 \quad \text{Eq. 7}$$

## 3. RESULTS

### *3.1 Connection between personality, aspirations and adoption*

We investigated the correlation between personality traits and aspirations. In the following chapter we discuss the association between these two intrinsic factors and its implication for the decision-making behavior of smallholder farmers in Kenya. The results from the Confirmatory Factor Analysis (CFA) on the latent variables are presented in Table 3. They show a good fit of the measurement model for the Big Five personality traits and aspirations. The observed variables for each latent construct are statistically significant with standardized factor loadings above 0.3 (Kang & Ahn, 2021). However, the indicator questions for neuroticism did not result in a valid latent variable. Subsequently, we used the respective indicator questions themselves in the following path analysis.

Table 4 and Figure 3 show the estimates from the structural model which analyzed the covariance between the latent variables. Table 4 includes all theoretically possible relationships and their respective standardized correlation coefficients. Except for neuroticism, all personality traits are intercorrelated. The lack of correlation here might be a result of the non-significant factor loadings (Table 3) that indicate that the construct of neuroticism is not identified correctly. The strongest positive correlation exists between agreeableness and conscientiousness, extraversion and conscientiousness and openness and agreeableness. The results show that three of the five personality traits significantly correlate with aspirations. Openness (0.41), conscientiousness (0.35) and extraversion (0.31) show a positive correlation coefficient. Furthermore, the neuroticism indicator nervousness, also significantly correlates with aspirations (-0.13), indicating that individuals that are prone to nervousness or anxiety are less likely to have higher aspirations.

This confirms our hypothesis that intrinsic factors such as personality traits do in fact, significantly correlate with the formation of aspirations. Conscientiousness is usually associated with efficient and hardwork-

**Table 3.** Factor Loadings of Measurement Model.

A. Estimates of factor loadings

| Factors | Items | Standardized factor loadings | SE | *p*-value | SMC |
|---|---|---|---|---|---|
| Agreeableness | forgiving | 0.49 | 0.07 | <0.01 | 0.24 |
| | considerate | 0.50 | 0.07 | <0.01 | 0.25 |
| Openness | artistic | 0.52 | 0.06 | <0.01 | 0.27 |
| | imagination | 0.80 | 0.07 | <0.01 | 0.64 |
| Conscientiousness | thorough | 0.40 | 0.07 | <0.01 | 0.16 |
| | efficient | 0.60 | 0.09 | <0.01 | 0.35 |
| Extraversion | talkative | 0.43 | 0.07 | <0.01 | 0.18 |
| | outgoing | 0.74 | 0.08 | <0.01 | 0.55 |
| Neuroticism | worrying | 0.48 | 0.55 | 0.38 | 0.23 |
| | nervous | 0.80 | 0.89 | 0.37 | 0.63 |
| Aspirations | educ. aspirations | 0.72 | 0.09 | <0.01 | 0.51 |
| | inc. aspirations | 0.33 | 0.09 | <0.01 | 0.11 |
| | soc. aspirations | 0.33 | 0.08 | <0.01 | 0.11 |

B. Covariances of measurement error

| Item 1 | Item 2 | Standardized correlation coefficient | SE | *p*-value |
|---|---|---|---|---|
| forgiving | talkative | -0.22 | 0.08 | <0.01 |
| imagination | efficient | 0.55 | 0.13 | <0.01 |
| worrying | nervous | 0.38 | 0.05 | <0.01 |

Note: SMC = squared multiple correlations.

**Table 4.** Estimates of the Structural Model.

| Relationship | Standardized correlation coefficient | SE | *p*-value |
|---|---|---|---|
| *Big Five personality traits* | | | |
| Openness ↔ Agreeableness | 0.74 | 0.12 | <0.01 |
| Agreeableness↔ Conscientiousness | 0.82 | 0.16 | <0.01 |
| Conscientiousness ↔ Extraversion | 0.81 | 0.13 | <0.01 |
| Extraversion ↔ Openness | 0.59 | 0.09 | <0.01 |
| Openness ↔ Conscientiousness | 0.47 | 0.12 | <0.01 |
| Agreeableness ↔ Extraversion | 0.95 | 0.16 | <0.01 |
| *Personality Traits - Aspirations* | | | |
| Openness ↔ Aspirations | 0.41 | 0.10 | <0.01 |
| Agreeableness ↔ Aspirations | 0.04 | 0.13 | 0.74 |
| Conscientiousness ↔ Aspirations | 0.35 | 0.13 | <0.05 |
| Extraversion ↔ Aspirations | 0.31 | 0.11 | <0.01 |
| worrying ↔ Aspirations | -0.07 | 0.08 | 0.40 |
| nervous ↔ Aspirations | -0.16 | 0.08 | <0.10 |

Fit indices: $c^2$ (*p*-value) = 0.1129; RMSEA = 0.031; CFI = 0.0.970; TLI = 0.947

Note: RMSEA = root mean squared error of approximation; CFI = comparative normed fit index; TLI = Tucker-Lewis index.

ing individuals (Costa & McCrae, 2017; Xu, 2020). In relation to aspirations, the literature is inconsistent, reporting positive or insignificant correlations of conscientiousness with (including economic) aspirations (Nishimura & Suzuki, 2016; Roberts & Robins, 2000; Visser & Pozzebon, 2013). Considering education and income aspirations as achievement-oriented goals, our results are consistent with Roberts and Robins (2000), who found high values for conscientiousness resulting in a significant effect on economic and achievement-oriented life goals.

Moreover, the results suggest that individuals that are open to new experiences and ideas, seeking excitement and socially outgoing also have a higher aspirations gap (Costa & McCrae, 1997; Xu, 2020; Zhao & Seibert, 2006). These are characteristics that can expand a person's aspiration window by providing information and ideas that might be passing by more close-minded individuals. Information and social networks play an important role for aspirations and in turn for livelihood choices and strategies of smallholder farming households. Agreeableness and the indicators of neuroticism did not have a significant effect on farmers' aspiration gap in our study.

As described earlier, SEM offers several advantages in dealing with theoretical constructs and hypothetical relationships. On the one hand, due to the limitations of the model, only correlations could be analyzed, not causality. On the other hand, however, considering that the data were collected after the actual intervention, it is reasonable to examine only correlations, as it would have been difficult to prove causality *ex post*.

### *3.2 Correlation analysis*

Aspirations are not only determined by personality, but also shaped by current context. We examined specific contextual variables and their correlation with educational-, income related-, and social aspirations to form a comprehensive idea of aspirations in a smallholder context. To this end, we examined the mean difference between individuals with above-average (high) and below-average (low) aspirations.

Table 5 presents the results from the correlation analyses. Educational aspirations are significantly correlated with a higher number of extension visits, more frequent travels outside of one's home village, smaller households, higher food security in terms of Months

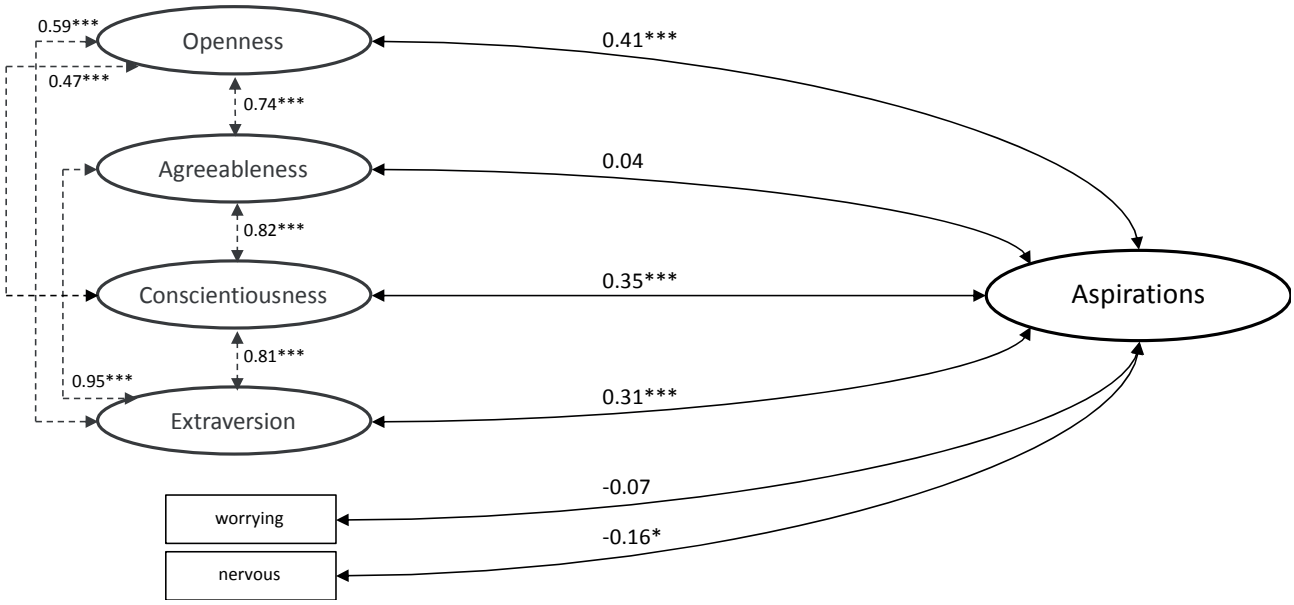


**Figure 3.** Path diagram presenting the estimated covariance coefficients from the structural model.

of Adequate Household Food Provisioning (MAHFP), higher education attainment by the household head or respondent, as well as a younger respondent and a larger number of memberships (to groups/ organizations). In households with high educational aspirations of the respondents, human capital, proxied by information (extension visits; travels outside of the village), education, age and social networks (memberships), is significantly higher. By providing positive examples, new ideas, different experiences, or new ways of looking at things, these aspects can have an increasing impact on the formation of aspirations (Chipfupa & Wale, 2018). It was shown that present resources function as restraining or enhancing factors to what is achievable (Elias et al., 2018). Moreover, higher food security also seems to provide a base for higher aspirations. Based on the 'Hierarchy of Needs', people are more likely to aspire complex future goals if their basic primary needs are fulfilled first (Maslow, 1943). The fulfillment of immediate needs is one of the primary drivers of decisions in rural Kenyan households (Mausch et al., 2021). Differing effects of household and respondent characteristics could therefore be due to differences in the ability to satisfy basic needs. Not having to spend the imaginative or cognitive capacity on worrying about the availability of food allows individuals to aspire for more than the satisfaction of basic needs (Nathan, 2005).

High aspirations regarding future income is associated with smaller farms, higher food security (MAHFP), and younger age of respondents. However, our results suggest that the determinants of aspirations are complex. On the one hand, food secure farmers might have the capacity to aspire more diverse life goals (including income and education) (Nathan, 2005). On the other hand, households with significantly smaller farms might rely more heavily on other income sources to cover immediate needs such as food, and with that, have higher aspirations for future income. Mausch et al. (2021) found a similar effect for households from Turkana (Kenya) that is characterized by difficult agricultural and economic conditions, where decision-making is based on the satisfaction of immediate needs rather than on the fulfillment of specific aspirations. Similar to educational aspirations, younger respondents also have higher income aspirations, in line with a previous study on aspirations in rural Kenya (LaRue et al., 2021). People at an older age may already have reached a considerable level of education and income. Therefore, aspirations for further increases may be lower than for people who have not yet reached a certain level of relative prosperity.

Social aspirations appear to depend mostly on resources and household characteristics. They are positively associated with agricultural training, travelling outside of the village and more frequent media use. Social aspirations can be linked with a broader information network and higher exposure to peers (Chipfupa & Wale, 2018). Furthermore, respondents in households that are worse off regarding the education level of the household head, food security (MAHFP), farm size and have experienced a higher number of shocks,

**Table 5.** T-Test/Mann-Whitney results on household and individual characteristics of respondents with below or above average aspirations.

| Variables | Education Aspirations | | | Income Aspirations | | | Social Aspirations | | |
|---|---|---|---|---|---|---|---|---|---|
| | low | high | mean diff. | low | high | mean diff. | low | high | mean diff. |
| *Extrinsic factors* | | | | | | | | | |
| monthly HH income (KSh) | 5898 | 5897 | -0.10 | 5739 | 6023 | 284.1 | 6066 | 5738 | -328.0 |
| access to credit | 0.62 | 0.66 | 0.04 | 0.67 | 0.62 | -0.06 | 0.67 | 0.62 | -0.05 |
| farm size (ac) | 1.96 | 1.83 | -0.13 | 2.16 | 1.69 | -0.46*** | 2.07 | 1.73 | -0.34** |
| agric. training | 0.57 | 0.65 | 0.08 | 0.60 | 0.61 | 0.01 | 0.52 | 0.70 | 0.18*** |
| extension visits | 0.68 | 1.06 | 0.38* | 0.79 | 0.94 | 0.15 | 0.85 | 0.90 | 0.05 |
| travel | 5.55 | 7.56 | 2.01** | 5.85 | 7.16 | 1.31 | 5.86 | 7.25 | 1.39* |
| shocks | 1.11 | 1.18 | 0.07 | 1.08 | 1.20 | 0.12 | 1.04 | 1.25 | 0.21** |
| *Household characteristics* | | | | | | | | | |
| HH size | 6.17 | 5.33 | -0.84*** | 5.76 | 5.72 | -0.03 | 5.65 | 5.82 | 0.17 |
| gender head | 0.79 | 0.78 | -0.01 | 0.76 | 0.82 | 0.06 | 0.83 | 0.75 | -0.08* |
| education head | 3.24 | 3.54 | 0.30* | 3.46 | 3.35 | -0.11 | 3.60 | 3.20 | -0.39** |
| MAHFP | 9.45 | 9.94 | 0.50* | 9.36 | 9.98 | 0.62** | 10.0 | 9.39 | -0.65** |
| *Respondent characteristics* | | | | | | | | | |
| gender resp. | 0.26 | 0.23 | -0.03 | 0.26 | 0.23 | -0.03 | 0.25 | 0.23 | -0.02 |
| age resp. | 47.4 | 43.5 | -3.96** | 47.0 | 44.2 | -2.75* | 44.8 | 46.1 | 1.28 |
| education resp. | 3.16 | 3.46 | 0.30* | 3.29 | 3.33 | 0.03 | 3.27 | 3.35 | 0.08 |
| membership | 1.01 | 1.16 | 0.14* | 1.12 | 1.06 | -0.06 | 1.11 | 1.07 | -0.03 |
| media use | 9.54 | 9.62 | 0.09 | 9.33 | 9.78 | 0.44 | 9.04 | 10.1 | 1.05* |

Note: Low and high refer to below and above average aspirations. T-test/Welch mean differences are displayed. *** p<0.01, ** p<0.05, * p<0.1. HH = household, KSh = Kenya Shilling, MAHFP = Months of Adequate Household Food Provisioning.

have higher social aspirations than their counterparts. In fact, one would expect that households that are more disadvantaged would also be more likely to focus on their immediate needs than on the pursuit of social status. Nonetheless, the complexity of the formation of aspirations suggests that greater exposure to peers and information may also override the focus on immediate needs. Additionally, households within which the respondent stated high social aspirations are more likely to be female headed.

It is notable that the three dimensions show different combinations of their determining factors. Some of these factors might not directly determine or control aspirations, they do however, limit them (Nathan, 2005). The aggregate aspiration index (Table 6) shows consistent negative association of farm size and consistent positive effects of agricultural training and experiences of shocks with above average aspirations. Moreover, respondents from female headed households in general, show higher aspirations. Nevertheless, the effects differ across the factors and dimensions of aspirations under consideration.

Our results suggest that aggregating diverse directions of aspirations may mask individual differences in the importance of aspects of well-being based on differing backgrounds and preferences. Effects and preferences can overlap and influence each other at the individual level, but also interact within the household and the wider community. While income aspirations may be seen as part of basic human needs, social aspirations can be considered a human need higher up the "Hierarchy of Needs", which only comes into focus once the first basic needs have been satisfactorily fulfilled. Thus, the aggregate aspiration index could be a useful tool for assessing the general attitude towards the future, as well as the individual's agency and proactivity. However, when it comes to identifying specific socioeconomic characteristics that play a role in the formation of aspirations, looking at the individual aspiration dimensions is more likely to lead to a clearer picture.

## 4. CONCLUSION

We identified the role that personality traits as intrinsic factors play for the formation of aspirations and examined the influence of socio-economic household characteristics as control variables in this process.

**Table 6.** T-Test/Mann-Whitney results on household and individual characteristics of respondents with below or above average aspirations.

| Variables | Aspiration index | | |
|---|---|---|---|
| | < average | > average | mean diff. |
| *Extrinsic factors* | | | |
| monthly HH income (KSh) | 5899 | 5896 | -3.539 |
| access to credit | 0.66 | 0.62 | -0.04 |
| farm size (ac) | 2.05 | 1.68 | -0.37** |
| agric. training | 0.58 | 0.65 | 0.07* |
| number of extension visits | 0.75 | 1.03 | 0.28 |
| travel | 6.52 | 6.67 | 0.15 |
| shocks | 1.05 | 1.28 | 0.23** |
| *Household characteristics* | | | |
| HH size | 5.74 | 5.74 | 0.00 |
| gender HH head | 0.82 | 0.75 | -0.07* |
| education HH head | 3.51 | 3.24 | -0.27 |
| MAHFP | 9.69 | 9.72 | 0.03 |
| *Respondent characteristics* | | | |
| gender respondent | 0.26 | 0.21 | -0.05 |
| age respondent | 46.0 | 44.6 | -1.34 |
| education respondent | 3.30 | 3.33 | 0.03 |
| membership | 1.10 | 1.08 | -0.02 |
| media use | 9.23 | 10.06 | 0.83 |

Note: T-test/Welch mean differences are displayed. *** p<0.01, ** p<0.05, * p<0.1. HH = household, KSh = Kenya Shilling, MAHFP = Months of Adequate Household Food Provisioning.

The aim of our research was to gain insights into the intrinsic influences of smallholder farmers' aspirations towards an improved understanding of their decision-making. We provide insights for agricultural development projects and policies to understand the underlying mechanisms of decision-making. Ensuring the alignment of project goals with individual goals could significantly change adoption dynamics and the identification of clusters that could best utilize specific support mechanisms such as sustainable agricultural practices (integrating trees in farming systems, crop rotation and irrigation schemes). We found that three of the five investigated personality traits indeed significantly correlate with aspirations. These traits paint a picture of personality structures that might be conducive to high aspirations while facilitating the basis for proactive behavior. Open-minded, socially outgoing and conscientious individuals will most likely have higher aspirations, which in turn can lead to higher susceptibility to novel technologies and approaches.

Nevertheless, extrinsic factors also play an important role in this system. Our results suggest that different types of aspirations (e.g. education, income) are connected to different factors (e.g. food security, household size, age, group membership), indicating that understanding these differences with regard to the direction of aspirations is crucial. Moreover, most of the determining factors derived from the literature are rather inconsistent across settings. Therefore, it is necessary to contextualize methods and results in order to understand the process, which we aimed to contribute to by focusing on an agricultural setting within the global South. While social and human capital interact positively with educational and social aspirations, poverty is an essential factor that was found to shift the focus from complex future aspirations towards the satisfaction of immediate needs. This may warrant future research as it relates to different target groups for agricultural development efforts and could add to a more differentiated approach for the poorest segments as compared to those slightly better off.

Analyzing aspirations and different livelihood strategies prior to the design of agricultural development projects and policies can improve the suitability of these interventions for the target group. Research and projects must acknowledge that there is no 'one size fits all' solution for development. Individuals interact differently with opportunities and propositions based on their individual aspirations. For example, more introverted people, who may also have lower aspirations, might not only be more difficult to reach, but also need tailored interaction and support to realize and seize opportunities. Whereas achievement-oriented, outgoing individuals are more likely to need less support to adopt new approaches.

Future research needs to explore these complex connections in more detail, using quantitative methods to examine context specific correlations. This process could also be extended towards actual behavior, by assessing real life responses to interventions. By doing so, the role of personality traits and aspirations in a concrete context could be identified, further deepening the understanding of behavior in the agricultural development context, for achieving positive and sustainable livelihoods and well-being outcomes for smallholder farmers in the global South.

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## APPENDIX

**Table A.** Questionnaire sections on personality traits and aspirations.

| Variable | Question | Scale |
|---|---|---|
| Aspirations | | |
| social status present | Imagine the person with the highest level of social status in your community, this represents a 10. The one with the lowest level of social status in the community is represented with a 1. What is the level of social status that you have at present? (on the scale from 1-10) | self-set scale (1-10) |
| social aspirations | What is the level of social status that you would like to achieve? (could be higher than 10) | self-set scale (starting with 1) |
| income present | Imagine the person with the highest level of income in your community, this represents a 10. The one with the lowest income in the community is represented with a 1. What is the level of income that you have at present? (on the scale from 1-10) | self-set scale (1-10) |
| income aspirations | What is the level of income that you would like to achieve? (could be higher than 10) | self-set scale (starting with 1) |
| education present | Imagine the person with the highest level of education in your community, this represents a 10. The one with the lowest education in the community is represented with a 1. What is the level of education that you have at present? (on the scale from 1-10) | self-set scale (1-10) |
| education aspirations | What is the level of education that you would like to achieve? (could be higher than 10) | self-set scale (starting with 1) |
| Ranking of the three dimensions | | |
| We have asked you about three dimensions - income, social status and education. Now I would like you to tell me which of these three dimensions are the most important for you. Please assort 20 beans to the three dimensions, according to their importance for you. No beans assorted to a dimension means this dimension is of no importance for you. The more beans you assort to one dimension, the more important. | | |
| rank_in | How many beans would you allot for annual income? | number (0-20) |
| rank_soc | How many beans would you allot for social status? | number (0-20) |
| rank_ed | How many beans would you allot for education? | number (0-20) |
| Big Five | | |
| Do you see yourself as someone who… | | |
| bf1 | … works thoroughly? | Likert scale (1-5) |
| bf2 | … is talkative? | Likert scale (1-5) |
| bf3 | … worries a lot? | Likert scale (1-5) |
| bf4 | … has a forgiving nature? | Likert scale (1-5) |
| bf5 | … is outgoing, sociable? | Likert scale (1-5) |
| bf6 | … gets nervous easily? | Likert scale (1-5) |
| bf7 | … values artistic, aesthetic experiences? | Likert scale (1-5) |
| bf8 | … is considerate and kind to almost everyone? | Likert scale (1-5) |
| bf9 | … does tasks efficiently? | Likert scale (1-5) |
| bf10 | … has an active imagination? | Likert scale (1-5) |

Note: Own Source. Survey 2021.

**Table B.** Characteristics of the 272 sample households.

| VARIABLE | LAIKIPIA *(N=93)* | | THARAKA NITHI *(N=89)* | | KITUI *(N=90)* | | Total (*N=272*) | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| *Household head and respondent characteristics* | | | | | | | | |
| gender HH head (% female) | 0.39 | 0.49 | 0.12 | 0.33 | 0.11 | 0.32 | 0.21 | 0.41 |
| age HH head | 51.3 | 14.0 | 47.0 | 13.7 | 50.8 | 13.2 | 49.7 | 13.7 |
| main occupation HH head | farming | | casual labor | | casual labor | | casual labor | |
| education HH head | 3.24 | 1.47 | 3.62 | 1.60 | 3.29 | 1.67 | 3.40 | 1.59 |
| gender resp. (% female) | 0.75 | 0.43 | 0.77 | 0.42 | 0.74 | 0.44 | 0.24 | 0.43 |
| age respondent | 46.5 | 13.5 | 42.5 | 13.4 | 47.3 | 13.6 | 45.4 | 13.6 |
| occupation respondent | farming | | farming | | farming | | farming | |
| education respondent | 3.17 | 1.53 | 3.42 | 1.60 | 3.31 | 1.57 | 3.31 | 1.56 |
| *Household characteristics* | | | | | | | | |
| HH size | 5.88 | 2.96 | 5.21 | 2.23 | 6.18 | 2.56 | 5.74 | 2.65 |
| number of children | 3.19 | 2.15 | 2.31 | 1.27 | 2.86 | 1.59 | 2.79 | 1.75 |
| farm size (ac) | 1.78 | 1.28 | 1.56 | 1.26 | 2.35 | 1.76 | 1.90 | 1.48 |
| monthly HH income (KSh) | 5950 | 3407 | 6093 | 3556 | 5648 | 3770 | 5898 | 3580 |
| main income source | wage (43.2 %) | | wage (32.9%) | | wage (51.8%) | | wage (42.6%) | |
| MAHFP | 8.84 | 3.72 | 10.50 | 2.92 | 9.79 | 2.62 | 9.71 | 3.02 |
| number of extension visits | 0.97 | 2.25 | 1.17 | 2.45 | 0.49 | 1.02 | 0.87 | 2.02 |
| number of shocks (last 3 yrs) | 1.16 | 1.03 | 1.06 | 0.97 | 1.23 | 0.82 | 1.15 | 0.94 |
| *Decision-making* | | | | | | | | |
| agricultural | head | | joint | | joint | | head | |
| market | head | | joint | | joint | | joint | |
| livestock | head | | joint | | head | | head | |
| income off farm business | head | | head | | joint | | head | |
| income employment | head | | joint | | joint | | joint | |
| major expenditures | head | | joint | | joint | | head | |
| minor expenditures | head | | spouse | | spouse | | spouse | |
| loans | head | | joint | | joint | | joint | |
| *Respondent characteristics* | | | | | | | | |
| access to credit | 0.61 | 0.49 | 0.67 | 0.47 | 0.65 | 0.48 | 0.64 | 0.48 |
| number of days travelled outside of the village (for one month) | 3.89 | 4.91 | 8.06 | 9.91 | 7.91 | 10.1 | 6.58 | 8.81 |
| number of memberships | 0.96 | 0.84 | 1.03 | 0.74 | 1.28 | 0.78 | 1.09 | 0.80 |
| *Aspirations* | | | | | | | | |
| education aspirations | -0.01 | 0.29 | 0.04 | 0.27 | 0.01 | 0.23 | 0.01 | 0.26 |
| income aspirations | 0.00 | 0.34 | 0.02 | 0.34 | 0.01 | 0.33 | 0.01 | 0.34 |
| social aspirations | 0.03 | 0.36 | 0.02 | 0.20 | -0.01 | 0.23 | 0.01 | 0.23 |
| aspiration index | 0.02 | 0.61 | 0.08 | 0.56 | 0.01 | 0.51 | 0.03 | 0.56 |
| *Personality Traits (Big Five)* | | | | | | | | |
| agreeableness | 4.42 | 0.77 | 4.34 | 0.63 | 4.71 | 0.64 | 4.41 | 0.76 |
| openness | 3.70 | 0.98 | 3.70 | 0.92 | 4.29 | 0.89 | 3.88 | 0.99 |
| conscientiousness | 4.23 | 0.73 | 4.49 | 0.61 | 4.59 | 0.66 | 4.42 | 0.73 |
| extraversion | 3.83 | 1.02 | 4.00 | 0.89 | 4.24 | 0.96 | 4.01 | 1.00 |
| neuroticism | 2.54 | 1.04 | 2.63 | 1.00 | 2.42 | 1.05 | 2.52 | 1.04 |

Note: Own source.

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**ORCID**
RS: 0000-0001-5055-3402
EW: 0000-0003-0815-4816
UG: 0000-0002-9073-6294

# Exploring the effectiveness of serious games in strengthening smallholders' motivation to plant different trees on farms: evidence from rural Rwanda

Ronja Seegers*, Etti Winter, Ulrike Grote

*Institute for Environmental Economics and World Trade, Leibniz University Hannover, Königsworther Platz 1, 30167 Hannover, Germany*
*Contact author. E-mail: seegers@iuw.uni-hannover.de

**Abstract.** Addressing the global challenges of climate change and biodiversity loss requires the widespread adoption of sustainable agricultural practices such as agroforestry. In many Sub-Saharan African countries, however, agroforestry adoption rates remain low among small-scale farmers, with insufficient knowledge about the benefits being a major barrier. To close this knowledge gap and increase farmers' motivation to plant different tree species on their farms, this study applies a Role-playing game (RPG) as an awareness-raising tool. 72 small-scale farmers from Rwanda played the RPG and participated in pre- and post-game surveys. A comparison of responses before and after playing demonstrates that the RPG increased farmers' knowledge and attitude toward most tree-related benefits. Moreover, playing the game significantly strengthened farmers' motivation to plant more tree species on their farms. The findings were supported by debriefing results, confirming that RPGs are an effective tool to raise farmers' awareness and motivation on sustainable land use management.

**Keywords:** agroforestry adoption, on-farm tree planting, ecosystem services, role-playing game, serious game.
**JEL codes:** Q15, Q51, Q54.

## 1. INTRODUCTION

Since 1960, more than half of the world's tropical forests have been destroyed and at present, deforestation continues to increase (IUCN, 2021). Deforestation and land degradation pose serious threats to ecosystem functioning and the human food system. Especially in Sub-Saharan Africa, where the prevalence of food insecurity and undernourishment is among the highest in the world (FAO et al., 2021; Ndoli et al., 2021), small-scale subsistence farmers are severely affected by the consequences of forest conversion (Meijer et al., 2015). Strengthening the resilience of ecosystems and human livelihoods, therefore, requires the urgent and widespread adoption of sustainable agricultural practices (FAO & UNEP, 2020). Agroforestry, one sustainable land-use practice with trees as an integral part of the farming systems,

provides various benefits for human well-being and the environment, including provisioning, regulating, supporting, and cultural ecosystem services (Coulibaly et al., 2017; FAO, 2013b; FAO & UNEP, 2020; Gamfeldt et al., 2013; Garrity et al., 2010; Udawatta et al., 2019). Despite the numerous benefits of trees, however, adoption rates among smallholder farmers remain low in many Sub-Saharan African countries (Amare & Darr, 2020; Ndlovu & Borrass, 2021).

A large body of literature has already examined a variety of adoption barriers, which include lack of land tenure rights, high investment costs, limited access to credits, insufficient availability of planting material, high transaction costs, information asymmetries, and lack of institutional support (Amare & Darr, 2020; Arvola et al., 2020; Bettles et al., 2021; Jerneck & Olsson, 2013; Kang & Akinnifesi, 2000; Kehinde et al., 2022; Meijer, Catacutan, Sileshi, et al., 2015; Romero et al., 2019; Russell & Franzel, 2004).

Besides the importance to address such external barriers, researchers and policy-makers should not ignore the intrinsic motivation of smallholder farmers to adopt agroforestry systems. According to the Millennium Ecosystem Assessment (Millenium Ecosystem Assessment, 2005), ecosystem management depends on people's evaluation of the services provided by these ecosystems. It is therefore assumed that smallholder farmers are more willing to plant trees if they are aware of and positively evaluate the benefits of agroforestry systems. Nevertheless, smallholders value and plant trees predominantly for direct economic benefits such as product provision and income-generating opportunities (Ndayambaje et al., 2012). In contrast, they seem to disregard environmental benefits that are not directly observable in the short term (Karamage et al., 2016; Ndayambaje et al., 2012; Zubair & Garforth, 2006). This disregard may imply a lack of knowledge about the complex interactions within social-ecological systems (Lima & Bastos, 2019; Lima & Bastos, 2020). Insufficient knowledge about the linkages between ecosystem services and human well-being can therefore reduce farmers' motivation to plant trees (Coulibaly et al., 2017; FAO, 2013a), whereas increasing farmers' knowledge and perception can improve their motivation (Oduro et al., 2018). This assumption is confirmed, for example, by a study from Indonesia, in which an environmental information campaign increased the motivation of oil palm farmers to plant trees (Romero et al., 2018). To improve agroforestry adoption among smallholders, it is therefore important to close existing knowledge gaps and raise awareness of the benefits of trees (Bettles et al., 2021; Ndayambaje et al., 2021; Zhang et al., 2016).

One approach to raising smallholders' awareness about environmental concerns is serious games, among them role-playing games (RPGs). RPGs simulate realistic issues in a safe learning environment, in which players can experience alternative actions that do not affect their real lives (Barreteau et al., 2007; Salvini et al., 2016; Villamor & Badmos, 2016). This experience allows players to better understand the consequences and linkages of their actions within complex social-ecological systems (Le Page et al., 2016; van Pelt et al., 2015; Villamor & Badmos, 2016).[1]

Accordingly, RPGs have been increasingly used in recent years to better understand human decision-making behavior, and increase players' knowledge of sustainable resource and land use management (Barreteau et al., 2007; den Haan & van der Voort, 2018; Falk & Meinzen-Dick, 2021; Hardy et al., 2020; Jean et al., 2018; Medema et al., 2016; Moreau et al., 2019). For example, the RPG conducted by Salvini et al. (2016) in Brazil increased farmers' awareness of the need to adopt climate-smart agricultural systems to strengthen their resilience to climate change.

The findings of previous studies, therefore, suggest that RPGs may also be appropriate instruments to raise awareness about the importance and advantages of agroforestry adoption. Thus, this paper aims to investigate whether an RPG can improve small-scale farmers' perception of the benefits of trees and their motivation to plant different tree species on their farms. Specifically, the study explores whether there are significant differences in attitude, knowledge, and intention regarding tree planting between a group of farmers who played the RPG and a group of farmers who did not play the game. The RPG of this study was applied in the Volcanic Highlands of the Northern Province of Rwanda. The area is characterized by high population density, land scarcity, and steep slope farming, which have resulted in high deforestation rates and susceptibility to soil erosion in the past (Ndoli et al., 2021; Stainback et al., 2012). Although the government of Rwanda promoted the implementation of the fast-growing, exotic Alnus

[1] RPGs aim to address real-world challenges and are therefore designed for a primary purpose beyond entertainment such as education, training, and information exchange (Medema et al., 2016). Particularly in the context of human-environment interactions, RPGs are used to improve stakeholders' understanding of different viewpoints and the consequences of their behavior on a system's functionioning. In addition to sharing perspectives and knowledge, their goal is also to strengthen collective action to change the current functioning of a system. Although RPGs are only simplified representations of difficult issues, they can still reflect the complexity of a system by incorporating relevant dynamics and interrelationships. This makes them an important tool for supporting social learning and collective decision-making processes (Bousquet et al., 2013)

and Eucalyptus species to reduce soil erosion, the diversity of trees in the Volcanic Highlands remains low (Iiyama et al., 2018; Mukuralinda et al., 2016). The Volcanic Highlands of Rwanda, therefore, represents an interesting case study to promote the planting of more different tree species.

This paper begins with information on the study area, data, and methods used in section 2; presents the results in section 3; follows with a discussion in section 4, and ends with a summary and conclusion in section 5.

## 2. DATA AND METHODS

### *2.1 Study area*

The study was conducted in the Volcanic Highlands in the north of Rwanda, a small, landlocked country in Sub-Saharan Africa. The north of Rwanda is characterized by mountainous regions with altitudes of more than 2000 meters (Mukuralinda et al., 2016). During the two rainy seasons occurring between March and May/June and from September/October to December/January, annual precipitation accounts for more than 1200 mm (Ngarukiyimana et al., 2018). The population of Rwanda mainly consists of small-scale farmers who use almost 75% of the land for crop cultivation and cattle farming (Mukuralinda et al., 2016). Due to land scarcity and high population density, farmers occupy only less than one hectare of land, which is often located on steep slope areas. However, cultivation on steep slopes, high deforestation in the past, heavy rainfall, and increasing population densitiy exacerbate the already existing vulnerability to flooding, landslides, and soil erosion (Uwihirwe et al., 2020). These environmental hazards decrease the availability of fertile soil for food production, impairing farm productivity and crop yield, which severely affects the farming population's livelihood (Ndoli et al., 2021; Stainback et al., 2012; WFP & VAM, 2018).

### *2.2 Data collection and analysis*

For this study, data were collected from 72 smallholder farmers. The gender ratio of the sample selected for this study is balanced and consists of about 50% male and 50% female farmers. They have a mean age of 38 years and invested 8 years in education (Table 1). The average household size is six persons, about half of whom are dependent on other household members. Respondents own approximately 0.6 ha of land and generate two-thirds of their income through agricultural activities. Most farmers are members of agricultural cooperatives and have learned about agroforestry through previous projects. On average, they have planted three different tree species on their farms.

**Table 1.** Farmer and household information.

| Socioeconomic variables | Mean values | Standard deviation |
|---|---|---|
| Female respondents (%) | 49.32 | |
| Age | 38.15 | 10.76 |
| Years of education | 8.29 | 3.71 |
| Household size | 6.25 | 2.24 |
| Dependency ratio [1] (%) | 48.33 | |
| Size of land (ha) | 0.73 | 0.76 |
| Annual income (RWF) | 629,383.8 | 683,957.8 |
| Share of agricultural income (%) | 64.84 | |
| Cooperative membership (%) | 70.83 | |
| Social interactions [2] | 6.43 | 16.88 |
| Experience with agroforestry (%) | 73.61 | |
| Number of tree species planted on farms | 3.11 | 1.74 |
| Risk affinity [3] (%) | 88.89 | |

Notes: If mean values are shown, standard deviations are given in parentheses.
[1] Dependency ratio defined as share of dependent household members who are not counted as labor force due to young/old age or diseases in relation to total household size.
[2] Social interactions defined as number of people with whom respondents discuss their agricultural decisions.
[3] Risk affinity (binary variable) measured by stated willingness to plant a tree even if the yield is uncertain.
*** p<0.01; ** p<0.05; *p <0.1.

We conducted a mixed-method approach that includes both quantitative and qualitative data collection procedures. Figure 1 provides an overview of the single steps of our data collection processes. First, for the quantitative data collection approach, all farmers answered a pre-game survey that contained questions following the Theory of Planned Behaviour (TPB) developed by Ajzen (1991). This theory states that an individual's behavior is guided by intrinsic beliefs. Whether an individual performs a certain behavior or not depends mainly on the individual's behavioral intention. Intention, in turn, is composed of three components, namely attitude, subjective norms, and perceived behavioral control. Attitude refers to the individual's perception of the consequences of certain behavior and whether the individual evaluates the behavior as favorable or unfavorable. Perceived behavioral control relates to the individual's perception of possible obstacles and the extent to which the person assesses the performance of the behavior as easy or difficult. Subjective norms take into account whether other people would approve or disapprove of the performance of the behavior and the extent

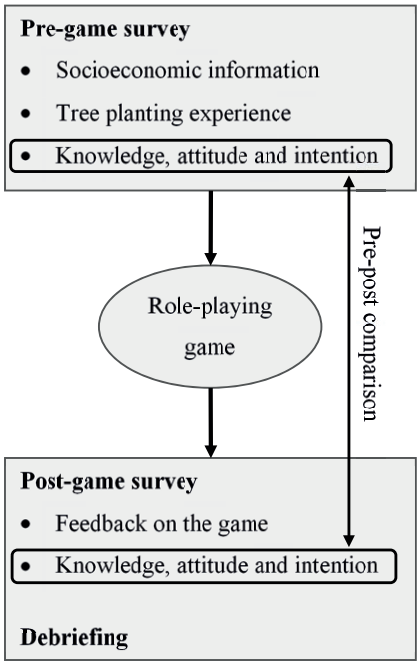


**Figure 1.** Data collection procedure.

to which the opinion of other people influences an individual's decision to perform a given behavior.

Since this study investigates the impact of an RPG to raise awareness and enhance, respectively change farmers' viewpoints towards positive perceptions of tree planting, we only include TPB constructs that are not affected by external factors. Since subjective norm is determined by the opinion of family members, friends, and other farmers, and perceived behavioral control is influenced by external adoption barriers such as insufficient access to markets, unavailability of tree seedlings, and small land area, we only include questions related to farmers' attitude and intention. In addition to these two original TPB constructs, we also include knowledge as an additional construct (Anebagilu et al., 2021; Maleksaeidi & Keshavarz, 2019).

We measure each construct by several indicator questions. Attitude includes eleven indicator questions and knowledge includes three indicator questions. As proposed by Meijer et al. (2015), the indicator questions of attitude are determined by multiplying the two measurement components salient belief and outcome evaluation. In our study context, salient belief describes farmers' expected outcome of diverse tree planting and outcome evaluation defines the personal assessment of this outcome. Concerning knowledge indicators, the first component specifies whether respondents think that specific knowledge of agroforestry is required to plant more tree species on farms and the second part describes whether respondents have this knowledge. All questions were asked on a five-point Likert scale. Both measurement components of attitude and knowledge indicators are multiplied, which resulted in a maximum final score of 25.

After answering the pre-game survey, all respondents participated in an applied RPG, which is further described in chapter 3.3. Afterward, participants conducted a post-game survey that contains the same questions on farmers' knowledge, attitude, and intention as the pre-game survey. In addition, the post-game survey also includes questions that are directly related to the game's outcome. To gain a more comprehensive understanding of the effectiveness of the game based on qualitative data, debriefings were held after the game sessions to discuss the results of the game. Game debriefings allow players to deepen their knowledge, increase mutual understanding between participants and translate their experiences into learning outcomes (Crookall, 2010; Eisenack, 2013; Mendler de Suarez et al., 2012; Meya & Eisenack, 2018).

The descriptive data were analyzed using Stata 14.2. Paired t-test was used to compare players' responses before and after the game.

### *2.3 Role-playing game*

The role-playing game used in this study is based on the "Upstream Downstream" game developed by the Partners for Resilience (PfR) program to build community resilience and reduce disaster risk (Mendler de Suarez et al., 2012). To increase farmers' knowledge of the multiple benefits of trees and to improve their perception of agroforestry systems, the game was adapted and expanded for the specific context of the study region. Players take on the role of subsistence farmers in mountainous areas who are at risk of crop failure due to heavy rainfall and flooding. To deal with shocks and maintain livelihoods, farmers have the option to cut down trees and sell wood, which in turn increases the risk of flooding in subsequent turns. For this study, two more elements were added to the game: the inclusion of trees of different species and the addition of scenarios related to various ecosystem services. Each game session consisted of eleven rounds and took about two hours.

The game board depicts a steep hillside landscape along a river and is divided into a mountainous upstream area and a flatland downstream area. While the upstream area has a higher tree density, trees are less common in the downstream area. Each farmer cultivates two neighboring plots that differ in terms of crop yield and flood

risk. The game includes three different types of trees: fruit trees, timber trees, and indigenous trees. Each tree species exhibits different characteristics (e.g., morphological characteristics such as height, leaf appearance, and flowering) that result in different contributions to economic and environmental benefits. Trees define the dynamic linkages between upstream and downstream farmers and determine the severity of precipitation's effect on crop and yield losses. The number of trees planted by upstream farmers can increase the damage threshold and thus reduce flood risk. Specifically framed scenarios reflect the different ecosystem services provided by different tree species (fruits, timber, soil fertility, pest control, pollination, climate regulation, and tourism). The scenarios reflect players' livelihoods in a resilient environment depending on the tree number and species diversity growing in their fields. The first three rounds were played without scenarios to ensure participants' understanding and familiarity with the rules of the game.

## 3. RESULTS

### *3.1 Tree planting*

The most frequently planted tree species by farmers from the study area and their reasons for planting are provided in Table 2. Most smallholders implemented Alnus, Avocado, Eucalyptus, and Tamarillo trees on their farms, which account for more than 70% of trees on their farms. A majority of these tree species provide multiple benefits but farmers' planting reasons for ecological purposes are rather monotonous.

The only ecological purposes for farmers to plant trees are soil erosion control and soil fertility improvement, with Alnus and Eucalyptus being the most preferred species to provide these benefits. Since Alnus and Eucalyptus are widely known as fast-growing species (Cyamweshi et al., 2021; Kuria et al., 2017), farmers of our study have planted them for timber production, stakes for climbing beans, and firewood. In contrast, they grow fruit tree species such as Avocado, Tamarillo, and Papaya exclusively for food production and income generation. Although agroforestry systems in Rwanda are dominated by exotic tree species, some farmlands also include indigenous species such as *Vernonia amygdalina* and *Erythrina abyssinica* (Mukuralinda et al., 2016). For example, 14% of farmers in our study region implemented Vernonia trees, with cultural backgrounds, use as fodder, and medicinal purposes being particularly important reasons for planting. Overall, our results show that most farmers are highly willing to plant more trees in the future, even if growth and yield are uncertain.

**Table 2.** Tree species planted by farmers.

| Tree species | Farmers who planted corresponding trees (%) | Most important planting reasons for farmers |
|---|---|---|
| Alnus | 75.00 | Stakes for climbing beans, soil fertility, soil erosion protection, timber, firewood |
| Avocado | 61.11 | Fruits, income |
| Eucalyptus | 50.00 | Timber, firewood, stakes for climbing beans, soil erosion control |
| Tamarillo | 37.50 | Fruits, income |
| Papaya | 16.67 | Fruits |
| Acacia | 16.67 | Soil erosion control, soil fertility, firewood, timber |
| Vernonia | 13.89 | Stakes for climbing beans, fodder, culture, medicine, soil fertility, soil erosion protection |
| Grevillea | 9.72 | Timber, stakes for climbing beans, soil erosion control, firewood |
| Erythrina | 6.94 | Soil fertility |

### *3.2 Game feedback*

Players' feedback on the game is illustrated in Figure 2. The results indicate that, although 38 players perceived the duration of the game as too long and one-third considered the game as too complicated, nearly all participants liked the game and had fun while playing. In addition, more than 75% of all participants agreed that the RPG represents their reality. In contrast, about 20% were uncertain about the game's ability to represent farmers' daily life, and only two players mentioned that the game was not representative. Despite this criticism, all farmers have expressed that they have learned something from the game. When asked farmers about their strategies followed during the game, 97% of farmers mentioned profit maximization, 51% indicated environmental protection, and 28% increased biodiversity. Results of the post-game survey furthermore show that, except for one farmer, all players consider it important to plant more trees in real life. Of these farmers, everyone emphasized the need to increase tree diversity on their farms and stated a higher willingness to plant trees in the future after they have played the game. The debriefing results also support the post-game survey responses of the farmers. For example, one player explained: "While playing the game, I diversified trees to support biodiversity. Now that I know the values of all trees, I would like to buy more species." Another farmer mentioned "What I learned is that indigenous trees are also important. I did not value them before but now,

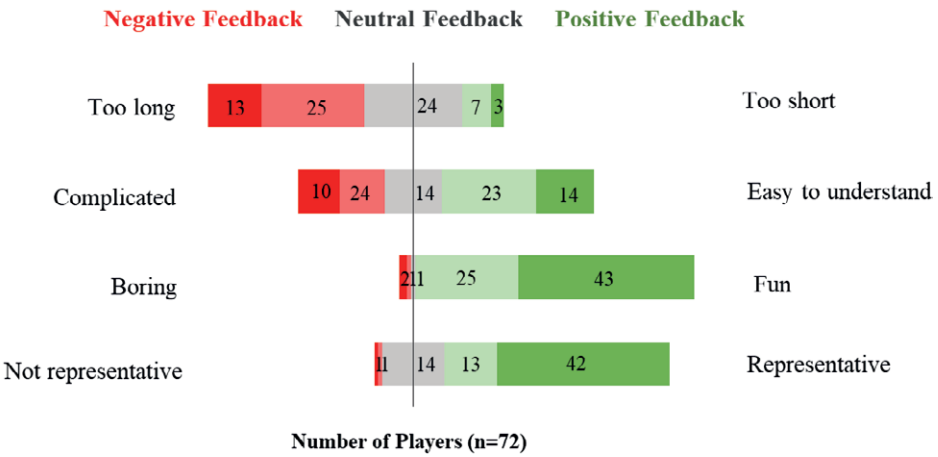


**Figure 2.** Players' feedback on the game. Note: Illustration adapted from Orduña Alegría et al. (2020).

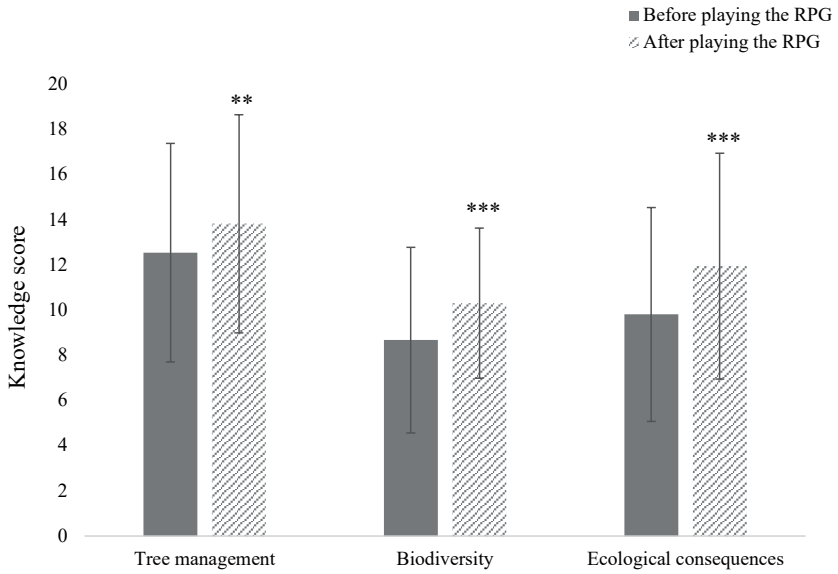


**Figure 3.** Comparison of farmers' knowledge score before and after playing the RPG. Notes: Mean values and standard deviations are shown. Maximum possible value of perception score is 25. *** p<0.01; ** p<0.05; *p <0.1.

after this game, I will start planting them on my farm." When players were asked why farmers do not mix trees with crops, they replied, "It is a poor mindset" and "lack of knowledge". This finding suggests that the RPG applied in this study is a useful tool to increase farmers' knowledge about the benefits of trees and improve their motivation to plant more different species.

### *3.3 Comparison of pre-game and post-game survey*

Figure 3 shows the results of farmers' knowledge scores before and after playing the RPG. The higher score values for all knowledge indicators imply that the RPG significantly affected farmers' awareness of knowledge requirements and skills related to agroforestry. Specifically, playing the RPG increased farmers' views on the knowledge needed for tree management. The higher awareness can be explained by the fact that farmers learned about the importance of the choice of tree species and the planting density on their farms. For example, the way players managed their trees affected not only their own livelihood in the game but also that of other players. The more trees players cut on their farms, the higher the likelihood that other players also suffer from flooding and soil erosion, leading to loss of crop yield and removal

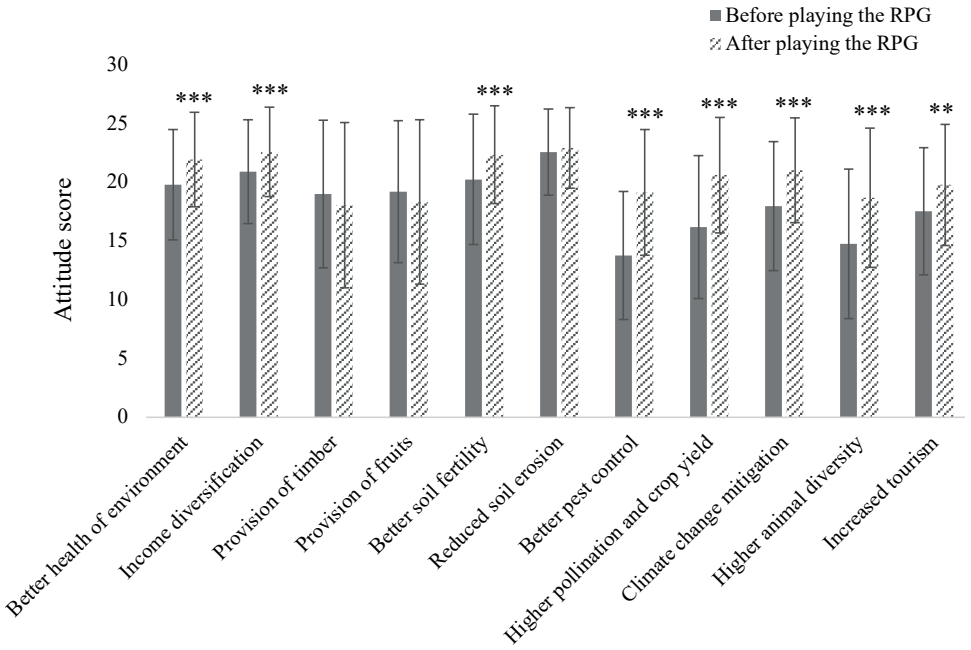


**Figure 4.** Comparison of farmers' attitude scores before and after playing the RPG. Notes: Mean values and standard deviations are shown. Maximum possible value of intention score is 25. *** p<0.01; ** p<0.05; *p <0.1.


**Figure 5.** Comparison of farmers' intention scores before and after playing the RPG. Notes: Mean values and standard deviations are shown. Maximum possible value of intention score is 5. *** p<0.01; ** p<0.05; *p <0.1.

of young trees. Likewise in a game debriefing, one player concluded "If farmers hardly mix trees with crops and they manage their trees poorly, they suffer crop and tree losses". At the same time, players noticed that the choice of tree species and the planting density also depend on external circumstances, such as farmland size, crop species cultivated, and tree-crop competition. For example, some farmers explained, "Planting too many trees on small farming plots will decrease crop yield". Thus, the debriefing results underline the finding that the RPG significantly increased players' awareness of the knowledge required to manage and benefit from trees. The game also significantly reinforced respondents' opinion that planting trees requires knowledge and that they have the required knowledge about the ecological consequences of trees and their impact on biodiversity.

Similar to knowledge scores, farmers significantly increased their attitude toward various benefits of trees

after playing the game (Figure 4). Most of the changes in attitude scores relate to indirect environmental services. Farmers revealed a significantly more positive perception, especially in terms of better environmental health, improved soil fertility, better pest control, increased pollination, climate protection, greater wildlife diversity, and tourism attraction. While farmers now also increasingly perceive trees as an opportunity for income diversification, the game did not significantly change farmers' attitudes regarding the potential of trees to provide fruits and timber and to reduce soil erosion.

Figure 5 illustrates the games' impact on the intention of farmers to plant more diverse trees on farms in the future. Concerning both farmers' stated intention and their self-assessed likelihood of planting diverse trees in the next three years, score values increased significantly after playing the game. Although the farmers were already highly motivated to plant trees before playing the game, the significant increase in their intention scores implies that the RPG is an effective and meaningful tool to further stimulate the intrinsic motivation of participants.

## 4. DISCUSSION

This study explored the potential of an RPG to raise smallholder farmers' awareness of the benefits of trees and increase their motivation to plant more different tree species on their farms. The results manifest our hypothesis that after playing the RPG, farmers significantly increased their awareness of the knowledge needed to plant different tree species on farms. After gameplay, farmers are more aware that tree planting requires knowledge about both tree management and the consequences of planting. Indeed, agroforestry adoption and management is more knowledge-intensive and requires more education and experience than conventional agricultural systems (Barrett et al., 2002; Mercer, 2004). Our result that farmers increased their awareness of knowledge requirements coincides with findings from other studies that revealed higher awareness among participants after gameplay (Moreau et al., 2019; Salvini et al., 2016). One example is the study by Salvini et al. (2016), which investigated the impact of an RPG on social learning and collective action among Brazilian farmers toward the adoption of Climate Smart Agricultural (CSA) practices. They found that the RPG increased farmers' awareness in terms of higher resource investments needed to implement CSA.

The RPG applied in this study furthermore strengthened farmers' positive attitudes towards the majority of tree-related benefits. The increasing positive perceptions towards most environmental benefits might stem from the game scenarios that raised farmers' awareness of the harmful environmental consequences of not planting trees or planting few trees, especially when tree diversity is low. Similarly, coffee farmers who played a RPG in Brazil learned about the positive environmental effects of agroforestry in terms of higher resilience to droughts compared to traditional farming systems (Salvini et al., 2016). Concerning knowledge acquisition, one player from our study declared during a debriefing session "The only way to learn about the consequences is through experience." As concluded in other studies, serious games create a safe environment in which players experience and learn from the consequences of their actions (Hardy et al., 2020; Mayer, 2009; van Noordwijk et al., 2020; Villamor & Badmos, 2016). RPGs, therefore, offer players the possibility to make decisions and explore alternative actions without taking real-life risks.

However, farmers of our study did not significantly change their attitude toward the potential of tree planting to decrease soil erosion and provide timber and fruits. The unchanged attitude towards these benefits can be explained by our finding that in real life, farmers have already planted most of the trees on their farms for soil erosion control and product provision. This result is in line with findings of Ndayambaje et al. (2012), who also noted that farmers in Rwanda have planted trees in the past primarly for economic reasons.

Although farmers' attitudes towards some tree-related benefits did not improve, the game still significantly increased their motivation to plant more different tree species on their farms. Our finding that the RPG increased farmers' intention to plant more different tree species on farms is in line with previous studies showing that serious games can lead to motivational or behavioral change (Janakiraman et al., 2021; Meinzen-Dick et al., 2018; Meya & Eisenack, 2018; Salvini et al., 2016). According to Meinzen-Dick et al. (2018), an applied RPG on watershed management increased farmers' motivation in India to adopt water registers in their real life and resulted in the introduction of rules for more sustainable groundwater use. Salvini et al. (2016) found that after gameplay, some farmers increased the area used for agroforestry systems on their land, while farmers who have not implemented agroforestry systems at the time of the study adopted coffee agroforestry and silvopastoral system after playing the game.

Although most studies emphasize the effectiveness of serious games to increase awareness of certain issues among participants, there are some studies criticizing that the knowledge gained through gameplay is not sufficient to alter stakeholders' behavior (Ducrot et al.,

2015; Lamarque et al., 2014). In this context, Lamarque et al. (2014) conducted an RPG with farmers to investigate how knowledge and valuation of ecosystem services influence their land-use decisions. However, the authors found that other external factors such as socioeconomic and topographic characteristics influence farmers' land-use decisions and outweigh the effects of ecosystem service valuation.

These contrasting study results highlight both the strengths and weaknesses of serious games. Although the application of serious games is an appropriate participatory method to reduce knowledge gaps and shift viewpoints, games represent only a simplified version of players' real life. In reality, they face additional challenges affecting their land-use decisions. To capture the entire socio-ecological system with all its elements, complex interactions and possible actions in the game is almost impossible and would lead to the game becoming unmanageable. To maximize the impact of a game while ensuring its representativeness and fun atmosphere, stakeholders should already be involved in the early design and testing stages of the game.

## 5. CONCLUSION

The purpose of the present study was to examine the impact of an applied RPG on small-scale farmers' knowledge, perception, and motivation to increase the planting of different tree species in a highly deforested area of the Volcanic Highlands in Rwanda. Comparisons of pre-game and post-game survey responses revealed that farmers significantly increased their awareness of the knowledge requirements for tree planting. Furthermore, the game significantly improved players' attitudes toward a wide range of tree-related benefits. After playing the game, participants expressed a significantly higher intention to plant more different tree species on their farms. Various statements made by farmers during the game debriefing sessions also confirmed the learning effect achieved through the game. Thus, this study provides empirical evidence of the effectiveness of RPGs in improving farmers' intrinsic motivation to adopt agroforestry.

Our study implies that insufficient awareness among smallholder farmers of the benefits of trees is an important barrier to tree planting that needs to be addressed. This paper, therefore, calls for more support to farmers to close existing knowledge gaps and promote agroforestry adoption. We recommend the use of serious games, which, as has been shown in this and other studies, are an auspicious tool to stimulate learning and support decision-making processes in sustainable land-use management, biodiversity conservation, and climate change mitigation (e.g. Andreotti et al., 2020; Meinzen-Dick et al., 2018; Salvini et al., 2016; Souchère et al., 2010).

As players criticized the duration and complexity of the RPG in this study, we suggest the participation of relevant stakeholders in every step of the development process of serious games. Early involvement would not only result in serious games that are fun and easy to understand but also helps researchers and policymakers to identify complex problems, constraining conditions, and feasible solutions to policy-relevant sustainability issues where actions are needed. In particular, the inclusion of a larger diversity of stakeholders can lead to both a greater expansion of personal views and knowledge and a commom understanding of the research gaps that need to be addressed (Menozzi et al., 2017). Stakeholder involvement is therefore key to successful game development and implementation (Barreteau et al., 2014). Overall, the strengths of RPGs to exchange knowledge, improve mutual understanding and collectively develop solutions make them a promising bottom-up instrument, which might be more efficient than conventional top-down approaches.

This study also comes with some limitations. First, we were interested in investigating the game's impact on farmers' intrinsic motivation but we have not considered whether a motivational change also leads to a change in farmers' actual tree-planting behavior. Overall, studies assessing the long-term effect of serious games and the translation of motivational changes into participants' real behavior are rare (Meya & Eisenack, 2018), offering scope for future research. Second, we have only examined farmers' intrinsic motivation as a superordinate factor and knowledge and attitude as subordinate components being influenced by the game. Beyond these components, farmers' motivation is also determined by their other intrinsic factors (e.g. subjective norms and perceived behavioral control) and extrinsic factors (e.g. farmers' socioeconomic and agroecological context). Thus, future research should focus on a combination of extrinsic and intrinsic determinants to better understand farmers' motivation and decision-making behavior in agroforestry adoption.

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