

Ndayisaba, Felix; Kansiime, Johnson; Teuber, Ramona

**Article — Published Version**

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Agricultural and Food Economics

**Provided in Cooperation with:**

Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale)

*Suggested Citation:* Ndayisaba, Felix; Kansiime, Johnson; Teuber, Ramona (2025) : A struggle for take-off: Farmers' perspectives on Rwanda's mushroom industry, Agricultural and Food Economics, ISSN 2193-7532, Springer Nature, Berlin, Vol. 13, Iss. 1, pp. 1-24,  
<https://doi.org/10.1186/s40100-025-00419-w> ,  
<https://link.springer.com/article/10.1186/s40100-025-00419-w>

This Version is available at:

<https://hdl.handle.net/10419/338264>

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RESEARCH

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# A struggle for take-off: farmers' perspectives on Rwanda's mushroom industry

Felix Ndayisaba<sup>1,2,3\*</sup> , Johnson Kansiime<sup>4</sup> and Ramona Teuber<sup>2,5</sup>

\*Correspondence:  
Felix.Ndayisaba@ag.uni-giessen.de

<sup>1</sup> International PhD Program in Agricultural Economics, Bioeconomy and Sustainable Food Systems (IPPAE), Justus Liebig University Giessen, Giessen, Germany

<sup>2</sup> Faculty of Agricultural Sciences, Nutritional Sciences and Environmental Management, Institute of Agricultural Policy and Market Research, Justus Liebig University Giessen, Giessen, Germany

<sup>3</sup> Faculty of Development Studies, Protestant University of Rwanda (PUR), Huye, Rwanda

<sup>4</sup> Department of External Environment for Agriculture and Policy Analysis, Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany

<sup>5</sup> Centre for Sustainable Food Systems, Justus Liebig University Giessen, Giessen, Germany

## Abstract

Mushroom cultivation represents an auspicious avenue to address poverty and food insecurity in land-scarce countries like Rwanda. However, nearly two decades after it was introduced in Rwanda's agricultural system, little is known about the farm-level practices, benefits, as well as the challenges facing the mushroom industry in Rwanda. Understanding these aspects is yet paramount to mark progress and identify future policy objectives. This study addresses the knowledge gap by examining farm-level practices, assessing the perceived benefits and challenges; and exploring how Rwanda's mushroom value chain is organised, based on the integrated value chain (VC), new institutional economics (NIE) and structure-conduct-performance (SCP) framework. We conducted non-participant observation and semi-structured interviews with mushroom farmers and official representatives nationwide; and performed content analysis using MaxQDA 24.3.0 to analyse the data. Our findings reveal an industry dominated by uncoordinated smallholder farmers, influenced by government-linked actors. Using locally available crop residues, imported cotton husks, and the seedling spawn sourced from a single government-recognised agency, farmers produce oyster mushrooms which they sell fresh to consumers and traders in major markets in Kigali, using commercial public buses as the main mode of delivery. In addition to the perceived role of addressing malnutrition, mushroom farming provides meaningful employment, rapid incomes and is a reliable source of livelihood. The major challenges include the absence of post-harvest handling technologies, limited farmers' knowledge, lack of spawn, and limited consumer awareness. These findings suggest that value chain development efforts should focus on improving farmers' knowledge, raising consumer awareness, diversifying quality spawn sources, and supporting farmers with the necessary equipment.

**Keywords:** Mushroom value chain, Mushroom cultivation, Rwanda, Juncao technology

## Introduction

Despite global commitments to end hunger, achieve food security and improve nutrition, malnutrition persists and one in three people worldwide suffer from food insecurity and undernutrition (United Nations 2022). In 2020, more than 149 million children under the age of five suffered from stunting, while about three billion people were unable to afford a healthy diet as of 2021 (FAO et al. 2023). The Africa Centre for Strategic

Studies revealed that 100 million Africans faced extreme poverty levels, while a quarter of a billion people in Africa were experiencing hunger in 2019 (Mupaso 2024). In sub-Saharan Africa, one of the major contributing factors to the prevailing malnutrition is the reliance on starchy staple foods such as cassava and sweet potato, which are characterised by low protein and micronutrient content (Ishara et al. 2018).

In Rwanda, although significant achievements have been observed in improving food security and nutritional status of households since the 1994 civil war and genocide against the Tutsis, hunger and poverty remain rampant in many households (Weatherspoon et al. 2017). Child stunting is estimated at 37.9% of children below five years of age, while the prevalence of undernourishment in the general population rose from 27% per cent in 2008 to 35.6% of households in 2020, and the country ranks among the most food insecure nations of the world (World Bank 2020). As is the case in many other low-income countries, Rwanda is grappling with the triple burden of malnutrition in the form of rampant undernutrition, inadequate intake of micronutrients, as well as increasing rates of overweight and obesity (Fan et al. 2017). In addition, structural bottlenecks, including land scarcity and fragmentation, climate change and high population density, continue to jeopardise the prospects for a food secure Rwanda. The country is the most densely populated in mainland Africa, with 525 inhabitants per sq. km and an average 0.3 ha farm size per household (Karangwa 2021), and the continued encroachment on marginal lands poses serious risks to biodiversity while inhibiting ecosystem restoration.

In the light of the above challenges, the government of Rwanda embarked on a plan to supplement traditional agricultural crops with the introduction of new, innovative agricultural technologies with the help of the Chinese Government, in line with the achievements of the 2006 Beijing Summit on China-Africa Cooperation and the Beijing Action Plan 2007–2009 (Government of Rwanda and Chinese Embassy Kigali 2008; King 2007). Among the new technologies that were introduced, *Juncao* mushroom cultivation technology retained considerable attention due to perceived affordability, adaptability, environmental suitability and its potential to combat poverty and malnutrition (Hua Xia 2023). Traditionally, mushrooms were not that common as food in many parts of the country, especially in cattle keeping regions. In most parts of the south, west and northern provinces, however, *Termitomyces* species and *Paxillus Brunneotomentosus* were predominantly consumed in rural areas (Degreef et al. 2016),

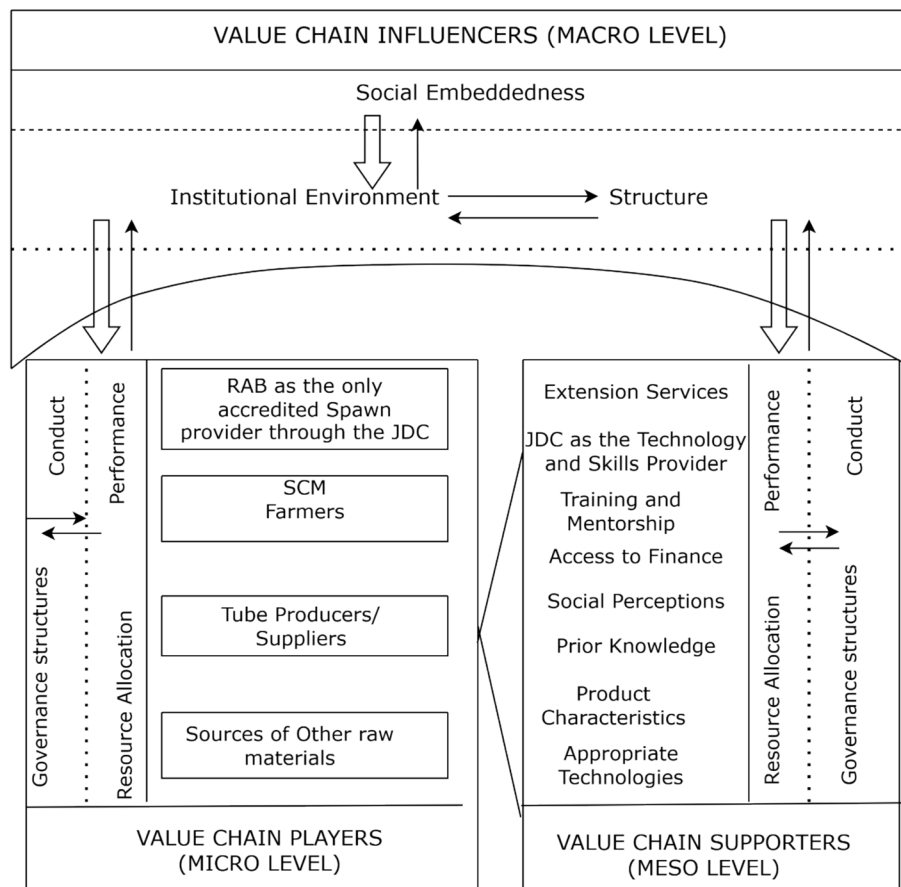
Upon its introduction in Rwanda's agricultural system, over 35,000 farmers were trained across the country, and the *Juncao* Agricultural Technology Demonstration Centre (JDC) was built at the Rwanda Agriculture and Animal Resources Development Board (RAB) headquarters in the southern province of Rwanda (Government of Rwanda and Chinese Embassy Kigali 2008). Mushroom cultivation was particularly embraced to alleviate pressure on land as it requires minimal space (Obaa and Nshemereirwe 2004; Zhang et al. 2014), is resilient to climate change, and is less dependent on atmospheric conditions (Saikat Roy et al. 2017). Moreover, mushroom cultivation can enhance food security by providing affordable and accessible alternative protein sources, while also improving the health status of households due to their numerous reported medicinal and dietary benefits (Dhanarajan 2017; Fernandes et al. 2021; Kakon et al. 2012; Beelman et al. 2003). Mushroom enterprises have also become an important source of employment and income to reduce poverty, especially in rural areas (Zhang et al. 2014).

Despite the political impetus that mushroom production has received in the country; however, little is known, almost 20 years later, on the programme's impact in improving local farmers' cultivation knowledge, and no effort has been made to explore the characteristics of the cultivated mushroom value chain in Rwanda. In a recent literature review examining mushroom cultivation in tropical Africa, Aa et al. (2024) confirmed that no study exists on the methods, challenges and prospects of mushroom cultivation in Rwanda. A comprehensive analysis of the entire value chain is thus essential to identify critical bottlenecks and opportunities for improvement. Likewise, there has been no study aimed at producing context-specific, empirical evidence on the socio-economic benefits of mushroom farming in Rwanda, and the factors likely to drive farmers' participation remain hitherto unexplored. The only existing literature on mushrooms in Rwanda confined itself to inventory the potentially wild edible mushroom species (Degreef et al. 2016), as well as to documenting possible substrate combinations for producing quality spawns (Ufitinema et al. 2023).

This study, therefore, aims to (1) understand how the cultivated mushroom value chain is organised in Rwanda; (2) ascertain social perceptions and perceived benefits of Speciality Cultivated Mushrooms (SCM); (3) identify the factors that drive farmers' decision to start a mushroom farm; and (4) explore the bottlenecks and prospects for the development of the mushroom value chain in Rwanda. The government of Rwanda considers horticulture as one of the key priority areas to generate employment, and mushrooms are counted among the major potential sources of export revenues (Government of Rwanda 2018). Hence, this study seeks to provide policy makers, farmers, and relevant stakeholders with the necessary information on the status and challenges facing the mushroom industry, so that adequate policies can be adopted for improvement. It is also meant to lay the foundation upon which further exploration could be undertaken. In the following sections, we discuss the theoretical framework employed, materials and methods used, the main findings and discussions thereto appertaining, as well as the general conclusions.

### **Theoretical framework**

To analyse the mushroom value chain, we adopt—with relevant modifications—the integrated value chain (VC), new institutional economics (NIE) and structure-conduct-performance (SCP) framework proposed by Jordaan et al. (2014) allowing for a comprehensive analysis of the incentive structure, inherent from the social, physical and institutional environments within which farmers operate (see Fig. 1). We maintain that the institutional advocates for the introduction of SCM aimed to alleviate poverty, enhance food security, and strengthen the country's agricultural export base. As a result, they continue to support the value chain through information sharing, training (whether paid or free), and other services to ensure its growth and competitiveness. Additionally, we assume that the SCM value chain interacts with key institutional, social, environmental and physical influences, whether negative or positive. These could be social norms, values, perceptions, and approval of peers, individual attitudes, infrastructure availability, rules and regulations, and positive or negative influences from local or country-level administrations.



**Fig. 1** Adapted conceptual framework for the analysis of the SCM value chain in Rwanda Source: Authors' own illustration based on Jordaan et al., (2014)

Located at the micro level are the value chain players, who are the actors involved from the input supply to the final consumer. Our study includes SCM farmers as primary producers of mushrooms and our main study group of focus, RAB as the governmental agency responsible for overseeing the value chain development and the JDC as the technology, tube and spawn supplier. At the meso-level, the value chain supporters help the players comply with any rules and regulations imposed by the value chain influencers located at the macro-level. In the context of our study, value chain supporters include providers of extension services, information, training, financial access, appropriate technologies and farm visits by experts from the Juncao Technology Demonstration Centre, prior knowledge and supporting product characteristics. Overall, value chain influencers could constitute the institutional environment, including local and country-level administration rules and regulations, societal norms, culture, values and the influence of societal structure on the SCM value chain.

According to the Integrated VC-NIE-SCP framework, farmers decisions and value chain development are nurtured by social embeddedness, the institutional environment at the macro-level, as well as the physical environment at the meso-level. We investigate the influence of such institutional arrangements that arise from, among other sources, the involvement of RAB and the JDC, peer and societal (dis)approval, the local

institutions and strong cultural environments within which farmers operate. We do this by asking questions about the genesis and motivation of the SCM business idea, the role and frequency of extension services, the knowledge, training and capacity building, the source of raw materials, marketing channels, access to funding and credits, as well as the constraints that SCM farmers face in general. Similarly, we explore the influence of social embeddedness by asking questions on how mushroom entrepreneurship came about or how the business is perceived within the respective communities. The emphasis has been placed on market participation as an important component of value chain analysis as in (Tarekegn et al., 2020).

### **Materials and methods**

As one of the earliest initiatives to examine the SCM value chain in Rwanda, this research is exploratory and qualitative in nature and has no inferential purpose. The main goal was to rely as much as possible on participants' views on the situation being studied (Creswell and David Creswell 2018; Sgroi et al. 2024). Semi-structured, in-depth interviews with mushroom farmers were used as the primary method of inquiry, while non-participant observation and documentation were conducted to gather additional information that could not be captured through interviews. Qualitative methods were preferred in this case because we intended to explore the subject on which little is known in the context of Rwanda, and to understand the experiences of participants, the context in which they act and the processes surrounding their behaviour (Bickman and Rog 1997). Qualitative approaches have been proven effective in many similar settings: for instance, they were successfully employed to explore the growing rural warehouse condominiums in Brazil (Filippi et al. 2019), to explore the potential of farmers' markets in Uganda (Nalubowa et al. 2024), to study the challenges related to mushroom entrepreneurship in Sri Lanka (Fernando et al. 2022), and to conduct a situational analysis of the mushroom industry in the eastern regions of Tanzania (Asman S. et al., 2006).

### **Data collection**

In total, 24 interviews were conducted, comprising 22 mushroom producers across the country, one government representative in charge of the mushroom programme at RAB, as well as the manager of the Juncao Technology Demonstration Centre in Huye, Rubona. To identify the potential respondents, we contacted the responsible officer at RAB, who provided us with a list of 145 farmers who were presumably engaged in the business at the time of our data collection, spanning from May to June 2023. Following a purposive sampling procedure, farmers were contacted by telephone to schedule interviews and farm visits beforehand. Of the 145 names received, some had already left the business, while others were not willing to participate in the study. The conditions for participation were farmers' willingness, which was demonstrated by the signing of an informed consent form, as well as active involvement in the mushroom cultivation business in Rwanda. Interviews were carried out in the local language, Kinyarwanda, except for the three interviews involving the officer in charge at RAB, the manager of the Juncao Technology Demonstration Centre, and one foreign investor which were held in English or French depending on the respondent's preferred language. It is also worth mentioning that, due to time constraints, the

officer in charge of the mushroom programme at RAB requested to have our interview questions sent in advance to allow them to provide written responses by email. Previous research suggested that electronic format interviews may be appropriate and satisfying (Stacey & Vincent, 2011). The geographical distribution of our sample is provided in Figure 2.

The interviews took place on sites of operation, and the researcher had the opportunity to observe, inquire and take pictures whenever necessary. There were two sections: the first dealt with the farm characteristics and farmers' socio-demographic profile, whereas the second dealt with questions pertinent to our main research objectives. To guarantee the respondents' confidentiality and anonymity, only the questions and answers in section two were audio-recorded, while the answers in section one were written.

As indicated in Table 1, the questions covered aspects across five categories: MVC and market linkages, challenges facing the value chain, individual factors influencing farmers' participation, socio-economic benefits of having a mushroom farm, and recommendations to improve the mushroom industry. These questions were first pre-tested with three mushroom farmers to ensure the validity of all the items, as in (Ferdous and Ikeda 2018). On average, the interviews lasted between 40 and 60 min, while the site-seeing and photo-taking activities took between 5 and 20 min, depending on the size of the area of operation.

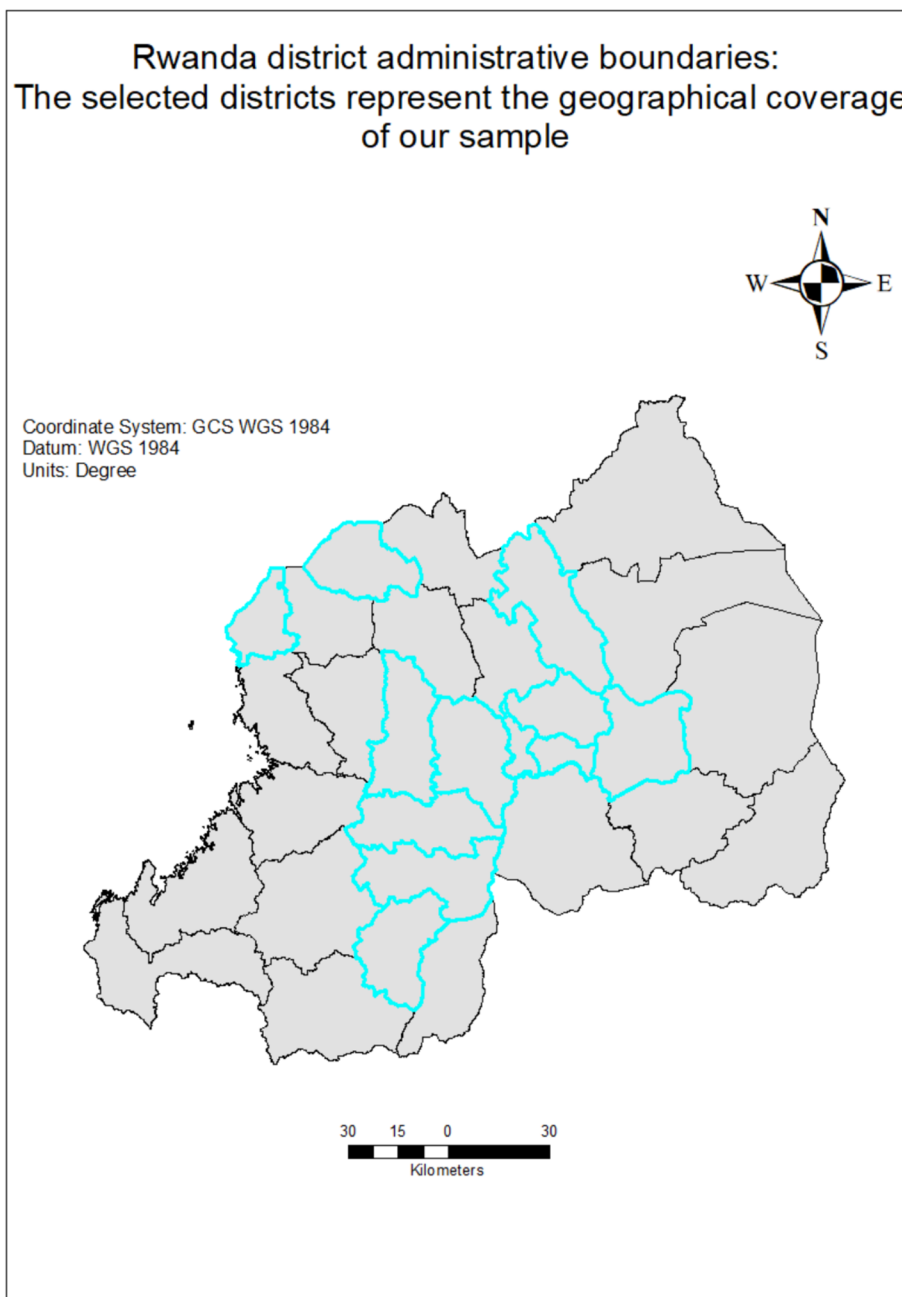
After interviewing the 22nd farmer, theoretical saturation was assumed. At this point, it appeared that going further would probably not elicit any new insights. In their recent review on theoretical saturation in qualitative research, Hennink and Kaiser (2022) concluded that sample sizes as small as nine to 17 participants could already reach saturation, whereby no additional data is found that would allow the researcher to further develop the properties of the phenomenon (Rahimi and Khatooni 2024). Similarly, Boddy (2016), further corroborating the findings from (Guest et al. 2006), concluded that samples of 12 may be cases where data saturation occurs among relatively homogenous populations. In their analysis of a study involving 60 in-depth interviews, saturation was reached on the 12th interview. Rao et al. (2023) also used 16 interviews to understand the phenomenon of food waste valorisation in the Netherlands, based on the recommendation from (Tesch R., 1984), suggesting that sample sizes should often vary between six and 25.

Nevertheless, as (Saunders et al. 2018) caution, data saturation should be operationalised in a way that is consistent with the research questions, the scope and the analytical framework adopted to avoid losing coherence and potency. Therefore, as this study was designed at the national level, attention was paid to including participants from various geographical regions of the country to account for slight differences in climatic conditions, dominant religions, cultural considerations, as well as cross-border influences as shown in Fig. 2. In similar settings, previous researchers have expressed the need to incorporate various geographic regions to enhance validity such as in (Kissi & Herzig 2024).

The district inclusion criteria were none other than being on the list obtained from RAB. It should also be noted that some districts, due to their geographical and socio-cultural contexts, were less likely to have mushroom farmers.

**Table 1** Example of questions that featured in the interview discussions. Source: Authors' own illustration

Theoretical concepts	Aspects covered	Indicative questions
Marketing channels Input Supply	Mushroom Value chain & market linkages Sources of spawn and other raw materials for substrate formation	Could you tell us where you mostly sell your produce? Please tell us about any marketing contracts with buyers prior to cultivation, if any Where do you get the raw materials for making the mushroom substrates? Where do you get the seedling spawn? How much does it cost you?
Social embeddedness	Family members and neighbours' perceptions on the mushroom business	How did your wife/husband perceive the idea of mushroom cultivation at start? How is mushroom cultivation regarded in your area? How does mushroom cultivation benefit your community?
Source of information + prior knowledge	Motivation and drivers for farmer's participation	How did the idea of mushroom cultivation come to your mind? Why did you decide to start up a mushroom farm?
Product characteristics + performance	Perceived benefits of having a mushroom farm	What attributes do customers prefer when it comes to buying mushrooms? How much of mushrooms do you harvest per tube? What do you see as the benefits of owning a mushroom business?
Resource allocation	Budgeting, Financial and non-financial resources management	How much do you spend on substrates? How many days do you work on your farm in a week? How many people do you employ on your farm? What is the daily/monthly wage for your employees? What is the surface area dedicated for mushroom activities?
Extension services, training, mentorship, technology	SCM cultivation knowledge & technology	When, and where did you learn how to grow mushrooms? Do you use Juncao technology on your farm? What does it consist of? How often do you get training? How would you evaluate the quality of extension services you receive, if any?
Governance structures & Institutional environment	Access to finance Available infrastructure	Where did you get capital to start with? Have you ever applied for a loan to start or expand your business? How do you transport your harvest to the market? How do you handle the freshly harvested mushrooms? What is the packaging procedure? What are the relevant government regulations that must be followed?



**Fig. 2** Geographical representation of the sample: The selected districts are Gasabo (3), Gicumbi (3), Huye (2), Kamonyi (1), Kicukiro (2), Muhanga (3), Musanze (2), Nyanza (1), Nyarugenge (1), Ruhango (1), Rwamagana (2), Rubavu (1); the numbers in brackets represent the number of respondents per district Source: Authors' own drawing

### Data analysis

The recorded material was manually transcribed verbatim prior to being translated from the original language to English. In addition to the authors' version of the translated scripts, an independent certified translator was employed to confirm the accuracy of the translations. Participating farmers' direct identifiers were removed, and the files were

named alphabetically from A to V. The final file transcripts were then imported into MaxQDA 24.3.0 for content analysis. Data were manually analysed using a deductive-inductive approach (Schüßler et al. 2024). In the first round, the transcripts were read thoroughly to enhance familiarity with the data and derive important categories under which deductive codes were built. In the second round, transcript files were carefully read one by one to derive any important code segments that could potentially be meaningful to our research objectives through a process generally referred to as inductive coding. Text fragments were assigned codes to classify textual data units into smaller units/categories (Specht et al. 2016). To enhance rigour, transcripts and codes were assessed by all the authors and, after consultations, minor modifications were adopted to obtain a final set of codes for the analysis.

## Results and discussions

### Demographic characteristics of respondents

The respondents were evenly distributed among men (50%) and women (50%), and their ages ranged from 29 to 57 years. Almost half of the respondents were found within the age range of 30–40, while the other half were aged 40 years and above. The longest experience in mushroom cultivation among the respondents was 17 years, as reported by two farmers who started their mushroom farm in 2006, whereas the shortest experience in the mushroom business was just four months at the time of our data collection. Most of the respondents had been involved in the mushroom business for more than five years at the time of data collection.

Another interesting fact is that, among the 22 farmers interviewed, more than half were highly educated. Three had a master's degree, eight had completed their university education and one had achieved a college diploma. Those with a high school diploma were eight, whereas only two farmers had not attained any secondary school education.

To have a good understanding of possible heterogeneity within our results, we conducted disaggregated textural analysis via key demographic characteristics, notably, gender and age groups. We aimed at ascertaining if some text codes were more prevalent in one age group or gender category compared to the others. The results of this process revealed that there were no remarkable differences between male and female respondents in terms of all the aspects investigated in this study. This was also true for age categories implying very little, if any, to no notable heterogeneity across demographics in our sample.

### Early days of mushroom cultivation in Rwanda

Starting in the early 1990s, mushroom domestication had already been introduced in Rwanda by ENABEL, a Belgian development agency and TechnoServe, an American philanthropic firm as these farmers noted:

*'I worked with TechnoServe before the genocide took place in 1994. I would say that they utilised rudimentary means, a few straws that generated very small quantity of mushrooms. So it has evolved'* (Interview with farmer H, Pos. 9);

*'There was a Belgian project at Rubavu, where I originate from, called PADEC before the war. Mushrooms were grown in Mahoko. There was an old lady that cultivated them'* (Interview with farmer M, Pos. 4).

Later, other non-governmental organisations such as World Vision and CARITAS continued to support and promote the development of edible mushroom production, the corollary of which can be synonymous with slow, uncoordinated, and staggering establishment. The philanthropic philosophy that incubated any mushroom cultivation initiative later revealed itself to be a hump in the development of the industry. None approached it from a business perspective as farmer A observed:

*‘What happened historically, the first thing, all the small farmers are people who have been trained by NGOs or the RAB, people who want to help produce, sometimes who give free tubes to start like that, but nothing behind!’* (Interview with Farmer A, Pos. 13).

It was often widows, orphans, rural youth and vulnerable members of the population that got trained, in most cases for promoting household consumption which, in turn, would combat malnutrition and its concomitant nutrition-related diseases such as kwashiorkor and marasmus which were significantly prevalent in the 1990s and shortly afterwards (Jay Rayner 2012). While this was a noble goal, sustainable production models were to be enhanced by the private sector through entrepreneurship. Moreover, since the prime of cultivated mushrooms in Rwanda was characterised by a strong emphasis on the poor and the sick, the general population regarded mushroom cultivation activities with contempt as reported by Farmer A.

It is also important to note that the implementation of the Juncao mushroom production technology in 2007 completely revolutionised the practice in Rwanda, with the introduction of new techniques for mushroom substrate preparation and mushroom tube sterilisation, which allowed for commercial production. However, given the challenges discussed herein, it appears the industry has not taken off even after then. Mushroom cultivation was still left out to the vulnerable groups with the support of NGOs with no consistent model for business growth and sustainability. By placing large quantity orders of mushroom tubes to distribute to beneficiary households, NGOs provided false hopes to the early adopters of the Juncao technology by injecting huge amounts of cash into their businesses. However, as in the following interview excerpt, many are now struggling to remain in the business since NGOs no longer place as big orders for mushroom tubes:

*‘...There was excitement in this area because of Care International, they had trained many hundreds and hundreds of people, so buying the mushroom tubes was a very good thing. There were cascading orders: a hundred tubes, another two hundred, three hundred, etc., and cash was flowing in.... Then I could purchase cotton husks and do many other things. Only then did I witness the project taking off! The project grew to a level, I started buying one ton of cotton, I had reached the ability to import cotton from Uganda, bring a truck full of cotton, put it there, cultivate, work and sell, but when the project stopped, people faced very serious problems related to money loss!’* (Interview with Farmer B, Pos. 7).

### **Social perceptions around mushroom farming and profile characteristics of the mushroom farmers**

Despite being touted as affordable and low capital investment, especially in rural, landless communities, mushroom entrepreneurship appears selective in the case of our study. As presented in Sect. 3.1, most farmers have a high level of formal schooling. On

the one hand, mushroom farmers, especially in rural areas are seen as very knowledgeable people and are treated with respect in their respective communities:

*'.....they think about you because mushrooms seem to be peculiar. They wonder, does he know about these things? They don't treat you as someone who lost occupation, but rather as someone with an increased knowledge and capacity. They say, you really went to school!'* (Interview with Farmer E, Pos. 13).

*'...when I started, it looked as if I was a fool. Not even one person would come to my house. But now, I am one of the opinion leaders!'* (Interview with Farmer N, Pos. 11).

On the other hand, mushroom entrepreneurship raises doubts and mockeries at start as farmers suggested:

*'...when I made the tubes for the first time, people did not eat the mushrooms that came out of it. They said, 'that dude has now gone mad!''..'*

This contrast reveals that mushroom farmers are those willing to absorb criticism and take risks for the uncertain future of their business, especially in a social environment that may not be acquired at the start. Even among these farmers who had not attended secondary school, one was motivated because they had worked with the Chinese as a machine operator since the start of the Juncao technology demonstration centre, and the other one had been frequently travelling outside of their community prior to embarking on a series of training from the other farmers. These results might thus signify the need to further explore possible avenues to render the business more inclusive to include even the lowest of the stratum of the society in rural areas.

When asked how big the area dedicated to mushroom activities was, eight farmers interviewed were unable to quantify it and simply stated that they did not know. This could be explained by the fact that most use their household compound for substrate preparation and raw materials drying, while some parts of the houses they live in are also used for either cultivation or mushroom tubes storage and inoculation. It was thus difficult for them to isolate the area for mushroom cultivation. Moreover, three respondents stated that they were using an area less than 20 sq. m for all activities related to mushroom cultivation, while three more others said they were devoting between 100 and 300sq.m for the business. Only two farmers held operations on more than 1000 sq. m, while majority operated on rather small pieces of land. Although a small number may specialise in producing tubes only, most farmers sell mushroom tubes to other farmers, while also selling fresh mushroom products to the market. It has also been observed that marginal farmers with less experience and limited resources usually start with growing mushrooms on purchased tubes. It is only after some experience that they also gradually learn how to produce mushroom tubes for themselves.

When asked to report on the type of mushroom they specialised in, almost all farmers explained that they grow no other variety, other than the Oyster mushroom (*Pleurotus ostreatus*). However, only one farmer was able to specialise in Button mushroom cultivation with the seedling spawn and technical guidance from a South African firm. From our field observations, few farmers had attempted other varieties, and samples of *Ganoderma* were presented to us. The absence of these other varieties from the Rwandan market is explained by two factors: first, as farmers reported, oyster mushroom presents features that are similar to the traditionally known, edible mushroom species in Rwanda,

making it the most preferred type of SCM by consumers. Second, inadequate skills and technical know-how, coupled with low capital and poor handling equipment make it extremely difficult for farmers to adopt and commercialise other new varieties.

#### **Origins of the idea, as well as the reasons to start a mushroom farm**

Data analysis revealed that the mushroom business idea emanated principally from media advertisements and people-to-people interaction (word of mouth), which were the most coded segments in this section. These were followed by curiosity-led information search and prior hands-on experience as the other important sources of the mushroom business idea, each accounting for three references that attest to it. Market observations, campaigns and outreach, RAB visits, or secondary school idea were also reported to a lesser extent.

Only about 20% of the respondents were engaged in the mushroom farming with a profit maximisation ambition, with huge capital investments. Some also were interested in trying out new things and to introduce novel crops in their communities (innovation driven), while others wanted to contribute to addressing the malnutrition problem in Rwanda (social motives). While farmers were given the possibility to highlight several motivations to start a mushroom farm, we note that none of the respondents claimed to have started mushroom farming due to environmental considerations.

Although previous scholars suggested that mushroom farming could be one of the means to mitigate climate change by producing quality protein with low CO<sub>2</sub> emissions (Dorr et al. 2021; Moxley et al. 2022), our results indicate that environmental protection standpoints hardly resonate with mushroom farmers interviewed in Rwanda. On the issue of resource minimisation and land scarcity, however, all respondents seemed to unanimously agree on the versatility of mushroom production and its limited requirements in terms of land and water.

#### **Value chain analysis**

##### ***Value chain players: sources of raw materials for mushroom tubes preparation***

With Juncao technology, the first step to grow mushrooms involves mushroom tube preparation. To make a mushroom tube, farmers have reported that they use local straw and residues from other crops such as beans, maize, rice bran, corncobs and saw dust (Wendiro et al. 2019). In other countries such as Brazil (Rolim et al. 2014) and, especially China where Juncao technology originated (Zhu et al. 2022), Juncao grass is an essential ingredient to mushroom tube preparation. However, in Rwanda where land scarcity and fragmentation is a major concern, only one farmer had planted the Juncao grass for use in mushroom tube production. Of a critical importance, instead, are cotton husks that most farmers perceive indispensable as they reported:

*‘...I make the tubes depending on what is available in the season. For example, those bags of sawdust. Sawdust is easily and quickly available. But the cotton husks must always be there. I therefore make a mixture of cotton husks, and other locally available materials such as rice bran, sawdust, straw from beans and rice residues, limestone and water. So, when one of those ingredients is not available, I use the other...’* (Interview with farmer G, Pos. 17).

However, as cotton husks become problematic due to rising costs and geopolitical tensions resulting into cross-border country restrictions, farmers are beginning to reflect on other viable alternatives, that mainly consist of using locally available materials for tubes preparation.

*'...We also used cotton husks, but we came to realise it is very expensive to import it from Tanzania or Burundi. They also realised that it was in high demand and increased the price, which therefore led us to adopting Juncao technology, which does not require out-sourced materials. If a farmer could not find utility with the maize straw and cobs, we buy it from them. We use rice bran, limestone, gypsum'* (Interview with farmer H-, Pos. 18).

Apart from cotton that is imported, other materials are found locally and at a low cost. Nevertheless, farmers still predominantly rely on cotton husk imports to execute large purchase orders since they face challenges of staple crop residue availability in large quantities. In addition, making large quantities of mushroom tubes based solely on substrates from local straw poses significant logistical and operational hurdles, because they occupy large spaces and volumes for drying and storage.

Mushroom tubes are sterilised prior to inoculation. Sterilisation takes place either by directly heating up the freshly manufactured tubes in a metal drum or by means of a steam steriliser. Although there have been recent attempts by farmers to develop their own spawn, the Chinese Juncao demonstration centre at RAB in Huye district still has the monopole to supply the seedling spawn to all mushroom farmers in the country.

#### ***Value chain players: packaging, transportation and selling points***

Although many farms are located outside Kigali city, most of regular mushroom consumers are found in Kigali as farmers explained. Interestingly, nearly 30% of the respondents indicated that they export their mushroom products to other countries. A notable example relates to one farmer who specialises in button mushroom farming, in addition to having oyster demonstration plots for the local market. They are now able to load a full truck with button mushroom to Nairobi. Others sell their produce to neighbouring countries like Uganda and the Democratic Republic of Congo, especially the neighbouring communities of Goma, which sits at the northwestern border with Rwanda.

Despite packaging and transportation involved, only two farmers reported having a proper packaging system, while others maintained that they put them in regular shopping bags or boxes and load them onto passenger carrier buses to Kigali city. Within Kigali city, mushroom transportation is often carried out on motorcycles, except if they are delivering to hotels. Here, it is important to underscore the difficulties mushroom farmers face when it comes to executing orders from hotels. Higher quality standards are required, and farmers are compelled to deliver their mushroom products on vehicles, conditions which de facto keep marginal farmers at bay, while inducing additional costs to farmers who sign selling contracts with them due to additional logistical hurdles imposed. Hence, since hotels do not pay any significant price premiums, farmers prefer selling their products on informal markets:

*'...I found that the informal market makes more money than the hotels, ....., there are quality certification documents that I was required by the hotels, which were difficult to get. 2nd, these contracts seem to be too much constraining because there are times the Hotel could tell me that they need only five kgs, and I would be obliged to use a car for*

*delivery. And that brings a lot of unnecessary expenses. On the same day, when I am almost finishing at three p.m, I would get their call again, ordering five kgs more. That means I would be obliged to go back to the collection centre to recuperate them and send a car to the hotel again! That is why it is sometimes difficult...*" (Interview with farmer N, Pos. 30).

When asked to describe the profile characteristics of their clients (mushroom consumers), there too, it appears that mushroom consumption is selective in terms of who gets to eat them. Mushroom buyers were mostly described using qualificatives such as intellectuals, rich, smart, powerful, luxurious, and civilised. Some farmers preferred to use softer tones by suggesting that mushroom buyers were those that understood the nutritional importance of mushrooms, or those that had the money to afford them. Farmers also noted that some of the buyers were influenced by their religious beliefs and practices, as some mentioned that their main buyers were belonging to the Seventh Day Adventists denomination or the *Abagorozi*<sup>1</sup> group. They also stated that there were those buying mushrooms because they were either suffering from diabetics or were simply undertaking efforts to reduce or stop meat consumption in their diets. It can thus be inferred that more work is to be done to encourage the public to consume mushrooms, notably by focusing on their nutritional and health outcomes.

#### ***Value chain supporters: post-harvest handling and processing***

Despite almost 20 years of promotion and practice, the findings of this study reveal that the specialty cultivated mushroom industry is still at its infantry stage in Rwanda. Most farmers interviewed had no other post-harvest processing techniques, and they relied heavily on quick fresh mushroom sales. Since mushrooms are highly perishable, they often have not more than 24 h to sell them and this exacerbates pressure on them, thus suppressing the market price. Post-harvest processing techniques have so far been limited to drying and selling either dry mushroom or mushroom powder, although to an extremely small extent. In the absence of sophisticated cold chains, only a handful of farmers have fridges where they can store their fresh mushrooms for three to seven days, they said. Only one farmer had established a cold chain for exports, while one other farmer had appropriate drying and mushroom grinding machines financed with the help of a UK based charity. Apart from the mushroom powder, as well as canned mushrooms that one farm also had to abandon at certain stage, most farmers interviewed sell the mushroom tubes and the spent substrates as the only by-products. None of the farmers interviewed reported selling any of the mushroom blended products.

#### ***Perceived benefits of mushroom farming in Rwanda***

##### ***Economic benefits***

This study also investigated the likely benefits of running such a farm in comparison to other traditional crops. From our observations and interviews conducted, mushrooms appear to be labour intensive. Therefore, most farmers reported that

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<sup>1</sup> A faction of the Seventh Day Adventists (SDA) that strongly opposes any form of meat, egg or diary products in the diet.

mushroom farming generated decent employment for farmers themselves, but also for the youth in their communities:

*'...I employ 10 permanent employees and casual workers...'* (Farmer N, Pos. 16).

*'...I employ 5 persons on a permanent basis. I pay them monthly salaries, feed them and lodge them due to the nature of our work. There are times we wake up at around 4 a.m to harvest. It would be difficult for them if they were not sleeping here, having to come from afar. After harvest and sending them off to the markets, they are allowed to return to continue their sleep and resume work at 8a.m'* (Farmer G-, Pos. 25).

Apart from employment creation, mushrooms were also appreciated by farmers in their ability to ensure them with a consistent cash flow to meet their needs such as school fees for the children, food, etc. They are particularly happy about the short waiting time to harvest, which gives them the ability to get cash every two weeks, a privilege that farmers of other crops do not enjoy as one farmer stated:

*'...growing mushrooms, I cannot be compared to the bean, banana or forest farmers because I always have cashflow. That means, if they are harvested after 15 days or so, and if I immediately take them to the market, you understand that I can solve whatever financial problem that may arise. It's different from a beans farmer who will wait for three months at least to harvest'* (Farmer K, Pos. 39).

In addition, farmers reported to have developed capacity for themselves by acquiring new assets, building new houses, purchasing land parcels, or even diversifying their agricultural activities by owning banana or rice farms.

Some challenges are worth mentioning, however: interviewed farmers claim that the price is never stable. In the wet season, when humidity is naturally guaranteed, markets become flooded with fresh mushrooms, and the price could go as low as 1500frw/kg in Kigali city. However, in the dry season, two things happen: there are no conditions for natural humidity, it is very hot and dry, thus creating a non-conducive environment for mushroom growth, coupled with the lack of cotton husks from Tanzania, especially in June because cotton harvest takes place late June in Tanzania. This situation will then reduce fresh mushrooms on the market to increase its unitary price to as high as 3500frw/kg. It should be understood nevertheless that farmers wish for an increased mushroom price to at least 3500frw/kg in the worst-case scenario for making profits. The reason is that, they claim, raw materials are becoming expensive. In neighbouring countries, they say, oyster mushrooms are priced higher. A kilo costs an equivalent of 3500Frw in Uganda, 7000FRW in Goma, eastern DRC while it could go as high as 10000FRW/kg as one moves further in DRC and Congo Brazzaville.

#### ***Social and environmental benefits***

Almost all farmers interviewed unanimously perceive mushrooms consumption as a means to combat hunger and malnutrition. Some, especially those in rural areas, reported to supply free mushroom tubes or mushroom based sauces to undernourished children in their communities, while additionally sharing relevant nutritional information and guidance on the cooking methods:

:

*'...I know it myself; we did it here in the village. We took the children in red and told their parents to come and give them mushrooms to cook. We got the kids out of red nutritional status (critical condition) quickly. Within a month, they had left critical condition!'* (Interview with Farmer O, Pos. 38–39).

*'...I'll give an example. I was working with the person in charge of youth at the district level. The babies of teenage girls that got pregnant at their homes had started showing signs of malnutrition and diseases. But when we gave them mushrooms for some time, we could immediately see the impact with our own eyes! When you see that the hair is fading, mushroom brings an immediate recovery!'* (Interview with Farmer C, Pos. 36).

As far as environmental benefits are concerned, although farmers reported that they were not motivated by environmental reasons to start their mushroom farm in the first place, it is interesting to note that they were keen to highlight numerous environmental benefits of owning a mushroom farm; the most cited example relating to the issue of land scarcity and land degradation in Rwanda. Also, most farmers were using spent mushroom substrates as soil compost, while others mixed it with chicken manure to produce the so-called 'soil protein'.

*'...If one is going to plant beans, they may be forced to cut down banana trees because beans cannot grow in a banana plantation. Or else, they may cut the forest and clear down the trees. But for mushrooms, I do not need a big plot of land because they are grown inside the house. What's more, the spent mushroom substrate can be used as a compost to boost productivity in other crops...'* (Interview with Farmer K, Pos. 27).

Circularity at the household level was also observed by Grimm et al., (2022), who conducted a SWOT analysis of mushroom cultivation in Uganda. Rural household farms were directly employing the spent mushroom substrates to fertilise the soils and improve other crop yields.

### **Challenges of the mushroom industry in Rwanda**

Our results generally point to a struggling industry with multi-faceted challenges which, if left unchecked would continue to slow down its take-off. First, the majority of farmers interviewed (80%) lamented the quality of spawn and the absence of spawn supplier competition. Since the Juncao Demonstration Centre within the Rwanda Agricultural and Animal Resources Development Board is the sole accredited institution to provide seedling spawn to mushroom farmers across the country, multiple times are when they have so many orders, which sometimes accentuates pressure on both sides as farmers reported. They also indicated that they do not get the seedling spawn whenever they request it, as they have to wait for months. The declining trust in the quality of the spawn from RAB led some farmers to begin to produce their own seedling spawn, although not yet endorsed by RAB and are, therefore, less trusted by peers:

*'...My seedling spawn produces more yields than that of RAB. They offer between 4 and 5th generation while I have the capacity to produce a third-generation spawn. Even now, there are many complaints and dissatisfactions about the seedling spawn from RAB'* (Interview with Farmer M, Pos. 38).

*'...We get it from RAB. There are times we lack raw materials. It can happen that we wait for the availability of the seedling spawn for quite a long time! Such situations are*

*often likely to stall our business activities. Worse still, it could be that they have a long list of farmers who ordered the spawn during the waiting, and then they say: 'Wait, we will start with those who applied first on the list...'* (Interview with Farmer V, Pos. 15).

Despite having a mushroom producers' forum as the official representative of the producers in Rwanda's Private Sector Federation (PSF), farmers expressed concerns over its shortcomings with regards to fulfilling its mandate. Farmers remain uncoordinated, competing for markets in a 'self-destructive' manner, constraining their agency in market price determination.

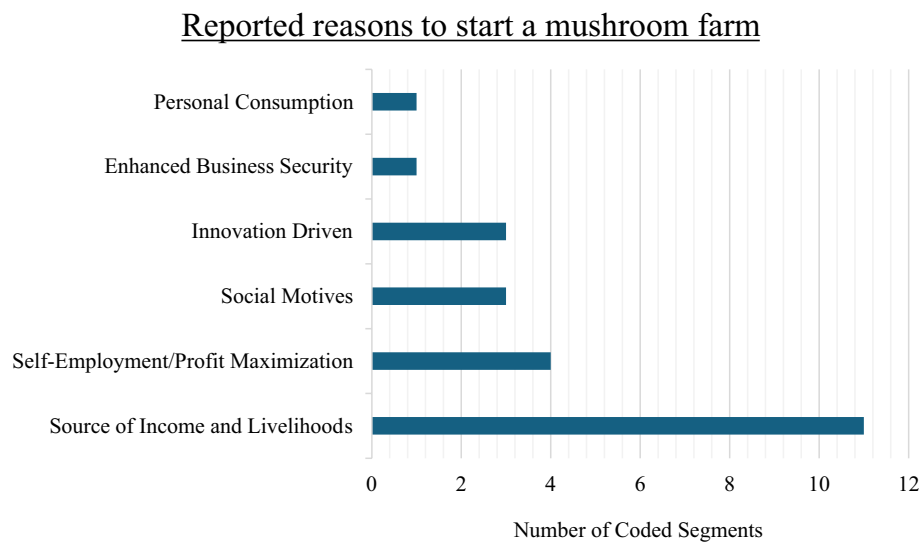
Another major challenge that farmers reported were dishonesty among value chain players, especially the producers of the '*imiginas*' (mushroom tubes) who often propagate the wrong information on the potential yields to attract customers. For example, they would say that one tube produces 1 kg or 2kgs of mushrooms. Even the RAB's initial technical guide on mushroom cultivation indicated that 1 kg of substrate produces 1 kg of fresh mushrooms, which is not the case as one farmer observed. According to farmers, 1 kg of substrate would produce between 500-600 g of fresh mushrooms maximum. The consequence of this wrong information is that many farmers overcalculate profits, sell at a lower price and quickly quit the business.

*'...We were noticing that the harvest is fast, fast but when you thoroughly calculate in the end, you realize it's a zero-sum game. Let's be honest with you, when we started, they were telling us that the tube produces 3 kg. At the market, a kilo costed 2000frw. Then we calculated and said, if we expect 6000frw from one tube in the end, then if we make 2500 tubes, we will become millionaires in a very short while! Now we discuss even with others and wonder why people deceived us and told us profits they don't get, just for us to be disappointed later? That is why in the mushroom business, new people come in while many more others are leaving!* (Interview with Farmer I, Pos. 7).

Other challenges include lack of training and appropriate knowledge on mushroom farming. Up until recently when new graduates from the College of Agriculture and Veterinary Medicine started joining in, only three farmers had had consistent training on mushroom cultivation for six months in China: demonstrating, once again, the crucial importance of the China-Rwanda cooperation in the establishment and development of the mushroom industry in Rwanda. Other farmers reported having had some sporadic training sessions for a few days through the support of RAB. However, there remains a significant number of farmers who reported having had no training whatsoever.

The lack of knowledge is also reflected in what they do. As our field observations suggest, some farmers run their businesses on a trial-and-error basis, and they were often unable to explain what they do and the mechanisms behind. As shown in Fig. 3, a farmer whose mushroom growing medium had been infected with the *orange mold* disease could not identify the problem. When they could not identify the problem, they asked peers in the WhatsApp group, and they told them that they had nothing to worry about. Other challenges such as lack of raw materials, lack of storage and processing equipment, inadequate transportation, and the perishable nature of the mushroom products have already been mentioned in the previous sections.

Although the farmers cited various environmental benefits of their enterprise, our field observations reveal that the practice is not completely environmentally friendly. It is still primarily dependent on traditional biomass as a source of energy, especially



**Fig. 3** Stated reasons to start a mushroom farm in Rwanda ( $n = 22$ )

during the mushroom tubes' sterilisation phase. Moreover, in addition to the already mentioned challenges, farmers cited the lack of tangible involvement and support from policy makers and agricultural development agencies as in the following excerpt:

*'We also want all the leadership to take it as important and promote this crop. People should know it as we teach about maize and beans. Marketing and sensitization should not be left to those who do business with it only. No one else talks about mushrooms! It is only spoken about by the people involved in the mushroom business in one way or another. But if it were taken up by different government programs, it would enable us to better reach out to those who are suffering from kwashiorkor as one of the remedies'* (Interview with farmer E, Pos. 63).

From the respondents' demographic characteristics, it is noticeable that mushroom farming is largely selective and mainly dominated by formally educated people, suggesting that efforts aimed at sustainably expanding the sector should focus on engaging a wider demographic that includes the young farmers and those with lower levels of education. One such promising undertaking in this regard is the rural community mushroom farming schemes such as one implemented in Musanze, whereby community members obtain mushroom tubes at preferential rates. This could serve as an inclusive model, lowering entry barriers and fostering broader societal engagement.

Regarding the genesis of mushroom cultivation in Rwanda, our findings reveal an initiative grounded on philanthropy, aimed at poverty alleviation and addressing nutritional deficiencies but devoid of sustainable business strategies. The early initiatives, often driven by NGOs, targeted vulnerable people, framing the enterprise as a welfare activity. This could have limited its mainstream appeal. Moreover, this charity motivated approach and perception could only leave the sector fragile especially upon project completion, by NGOs. This was indeed the reason why farmers faced sudden income declines later. While the introduction of the Juncao technology in 2007 was forward-looking, there is still no consistent private sector engagement. As farmers

noted, the Juncao Technology Demonstration Centre within the Rwanda Agriculture and Animal Resources Development Board remains the sole accredited institution to provide mushroom tubes and spawn throughout the country. It is also entrusted with the responsibility to train new farmers, and to provide mushroom farming related extension services nationwide.

Concerns with regard to the spawn supply monopoly and poor quality spawn have also been voiced by researchers like Higgins et al. (2017). To revitalise the industry, such institutional arrangements need to be revisited. Policy efforts could target broader involvement from both the public and private sector. This would further develop the industry, allow competition and value addition; while also benefiting the local economy. A case in point here is Farmer A who reported that their farm employed more than 150 residents of the neighbouring community and made weekly exports to Kenya, DRC, Tanzania and other markets in central and western Africa. This example demonstrates that, if taken seriously, Rwanda's mushroom sector can generate significant export revenues. However, a large-scale, commercial enterprise model should be embraced with caution. As Grimm et al., (2022) observed, despite being highly productive, commercial enterprises generate fewer returns in terms of ecological sustainability and societal benefits. Value addition and business model promotion efforts should be accompanied by initiatives to enhance rural community farms, which are most sustainable and socially beneficial.

As seen in the results section, following the initial introduction period, further adoption of mushroom production as a business was primarily driven by media exposure and word-of-mouth interactions followed by prior hands-on experience and own initiative information searching. Notably, formal and organised institutional arrangements played a smaller role. This points to diffusion patterns that are social and narrative-led, suggesting that efforts to attract new farmers in the industry need to focus more on storytelling, testimonies, people-to-people knowledge sharing, and media programmes. Regarding farmers' reasons to start a mushroom farm, the results shown in Figure 3 highlight that most entrants were motivated by livelihood goals align with prior work on the role of mushrooms in strengthening livelihoods. Researchers have, for example, stressed the potential of mushrooms to reduce vulnerability to poverty by constituting a fast yielding and nutritious source of food while being a reliable source of income (Ndikumana and Kanani 2015).

Social perceptions around mushroom farming revealed a two-sided narrative. On one hand, early farmers experience scepticism from other members of society which requires that they demonstrate resilience before gaining community acceptance and recognition. On the other hand, however, after some time, the society considers them well educated and smart due to their knowledge and innovativeness, which can drive the acceptance of the enterprise and its subsequent adoption. Regarding farmer and farm characteristics, our results revealed that most farmers operate on small household plots with only a few large-scale operations; supporting the notion that mushroom farming is a viable enterprise in land-scarce contexts (Aditya et al. 2024; Grimm et al. 2022; Donatha, 2013). The presence of some farmers who produce both mushroom products and tubes could imply that efforts to steer the sector to sustainability could also consider ensuring that beginners have access to affordable tubes while those that have spent some time in the business could be trained further to gradually transition into tube production. This would

create a self-sustaining production chain. To promote diversification beyond Oyster mushrooms, efforts should address consumer familiarity and farmers' technical, financial, and equipment constraints by expanding knowledge through trainings, field studies, and extension services. Benchmarking inception initiatives that sent selected farmers to visit Juncao technology centres in China for training and exposure, a similar endeavour could be pursued going forward.

Evidence from the value chain analysis section points to a sector in its formative stage, with challenges in input sourcing, distribution, and weak post-harvest handling practices constraining growth. The dependence on imported cotton husks implies a key vulnerability, as any disruption in cross-border trade would directly undermine production. The observed patterns in packaging, transport, and market access highlight an industry in which more lucrative markets remain inaccessible to many producers, leading to disparities between better-resourced farms and marginal operators. In turn, the rather small to modest consumer base, shaped by income, education, and lifestyle factors, signals the need to address not only logistical constraints but also consumer perceptions. The absence of advanced post-harvest handling and processing infrastructure further limits the capacity to capture value beyond the fresh produce, locking producers into quick sales with low margins especially at peak production. These dynamics imply that strengthening the Rwandan SCM industry will require coordinated interventions across the chain, from input diversification and market development to the introduction of technologies that can extend shelf life (Fig. 4).

Respondents' perceived benefits suggest that the enterprise offers a range of economic, social, and environmental gains. Economically, it provides decent employment not only for farmers themselves but also for youth in surrounding communities. The short production cycle creates a steady cash flow that enables farmers to timely meet regular household expenses compared to traditional seasonal crops. However, the instability of market prices, influenced by seasonal growing conditions and the cost and availability of



**Fig. 4** An orange mould infected mushroom plot (left) and the mushroom tube sterilisation process (right)  
Source: Authors' own fieldwork photos

key raw materials, remains a key constraint. It, however, seems that Rwanda still enjoys a comparative production advantage compared to neighbouring countries and this could be partly buttressed by respondents' reports of lower mushroom prices compared to the international market. This could make the country's products more affordable, competitive and could potentially increase its market share in those price sensitive export countries. Socially, mushrooms are perceived as an effective means to fight hunger and malnutrition, with some farmers sharing nutritional knowledge within their communities. Reported improvements in the health of malnourished children demonstrate the potential of mushroom farming as a viable solution to the problem. Regarding the environment, even though farmers were not initially motivated by ecological considerations, they recognised multiple benefits, especially in the context of land scarcity and degradation. The ability to cultivate mushrooms indoors without the need to clear land, coupled with the reuse of substrates in other farm enterprises as fertiliser, highlights the circularity of the practice. These results suggest that mushroom farming holds promises as a livelihood strategy that can simultaneously address income needs, improve community nutrition, and promote sustainable land use in the land constrained East African country.

The challenges identified point to fundamental structural and institutional weaknesses. Weak farmer coordination leaves producers competing in ways that erode their own ability to influence market prices. Dishonest practices, particularly the exaggeration of yield potentials by some tube suppliers, communicate unrealistic expectations, undermining long-term stability. The limited access to regular training and technical knowledge, for example jeopardises farmers' ability to identify and manage threats such as disease outbreaks. This concern, coupled with lack of awareness has also been previously reported among the major impediments to mushroom industry development in Swaziland and Malaysia (Mabuza et al. 2012; Tarmizi et al. 2013). Furthermore, previously identified constraints such as input scarcity, inadequate storage and processing facilities, and transportation difficulties, compound the sector's vulnerability, particularly given the perishability of mushrooms. Environmental considerations also remain a double-edged sword: while the sector promotes certain sustainable practices, such as substrate recycling, its dependence on biofuels in sterilisation processes could reduce its overall environmental benefits. The absence of strong policy engagement and public awareness initiatives further limits the sector's visibility and integration into national agricultural strategies. Without targeted interventions to address these systemic issues, the mushroom industry risks remaining marginal, unable to fully capitalise on its economic, social, and environmental potential.

## Conclusions

The present study has qualitatively investigated the mushroom value chain and industry development in Rwanda, focusing on farm-level practices, social perceptions, marketing channels, harvest handling and processing, as well as the factors driving mushroom entrepreneurship in Rwanda. Overall, farmers are motivated by potential earnings, as they regard mushroom enterprises as a means of ensuring livelihoods. In most cases, the idea to start a mushroom farm transmits through storytelling, word of mouth and media broadcasts from the Rwanda Broadcasting Agency (RBA). Despite the numerous

challenges facing the industry as discussed herein, the findings reveal that mushroom production has the potential to address poverty and malnutrition by generating rapid incomes while, simultaneously, ensuring access to safe, high quality protein foods to households in both urban and rural areas. Farms based in rural areas are more likely to contribute to this goal, by notably, providing mushroom tubes to willing families at no cost, offering training on cooking methods and raising awareness on the role of mushrooms. Farming households in rural areas attest to the crucial role mushroom farming has played in improving their livelihoods and financial independence.

As farmers consistently emphasised, more political engagement and government follow-up are essential to enable the industry to achieve its intended goals. There exist well elaborated policy frameworks for staple crop production and cash crops like tea and coffee, but no policy has been hitherto established to promote the mushroom industry as the officer in charge of the mushroom subunit at RAB confirmed during our interview. They did mention, however, that a policy addressing this matter was under development, and that its publication was expected in the next few years. Hence, this study is of a paramount importance at this juncture of Rwanda's mushroom policy development, and the insights contained herein could serve as a useful reference for evidence-based policy formulation.

Finally, our study has the following limitations: first, the data were collected based on a sample from the list provided by the officer in charge of the mushroom subunit at RAB. This might inherently cause a selection bias since independent producers who had no connection with RAB whatsoever were not considered. Second, since our interest was to probe the respondents' views and opinions on the mushroom industry, our results are not authoritative, and generalisations should be made with caution. Lastly, our value chain analysis does not include other key players such as traders, middlemen, and consumers. Our results are, thus, predominantly based on producers' standpoint. We believe, nevertheless, that this constitutes an empirical basis for further explorations, and follow-up inquiries into the subject with either qualitative or quantitative methods are vigorously encouraged. For instance, since local farmers are less enchanted with the idea of selling in star-rated Hotels, it could be insightful to investigate the sources and types of mushrooms served in major hotels in Kigali city, especially in the current context where no data exist on imports and exports volumes.

### **Ethics and consent to participate**

The research protocol was approved by the ethics committee of the Protestant University of Rwanda, and a prior written informed consent form was signed by all participants, after taking ample time to explain that participation is voluntary and that the refusal to participate would bear no consequence whatsoever.

### **Acknowledgements**

The authors would like to express sincere gratitude to all interviewed mushroom farmers for their valuable time and responses.

### **Author contributions**

F.N and R.T designed the research, analysed the data, and wrote the results. J.K developed the conceptual framework and contributed to the discussion section. All authors equally contributed to the writing and proofreading of the manuscript.

### **Funding**

Open Access funding enabled and organized by Projekt DEAL. Financial support from the German Academic Exchange Service (DAAD) under the programme Development-Related Postgraduate Courses (EPOS) funded by the Federal

Ministry for Economic Cooperation and Development (BMZ), contract number P1401273, is gratefully acknowledged. The authors would also like to thank the FIAT PANIS Foundation which financially supported data collection activities.

#### Data availability

Data will be made available upon reasonable request addressed to [Felix.Ndaiyisaba@ag.uni-giessen.de](mailto:Felix.Ndaiyisaba@ag.uni-giessen.de).

#### Declarations

##### Competing interests

The authors have no financial or non-financial interests in the manuscript.

Received: 10 December 2024 Revised: 1 September 2025 Accepted: 2 October 2025

Published online: 13 October 2025

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