Assessing the Potential of Digital Tools to Enhance Transparency and Traceability in The Cocoa Value Chain in Ivory Coast

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ABSTRACT

Problem

The cocoa industry in Ivory Coast faces significant challenges related to market access, income and transparency despite being the leading global cocoa exporter.

Research Aim

Therefore, this mixed-methods study aimed to assess digital solutions to address these issues by improving traceability and empowering Ivorian cocoa producers.

Research Method

Surveys and interviews were conducted with 12 farmers in Lôh Djiboua, 5 buyers, and 3 experts.

Results

The key findings revealed that 72.7 per cent of farmers were willing to adopt a mobile app to enhance productivity and connect with buyers. However, barriers like limited digital literacy and poor rural infrastructure were identified.

Implications and Recommendations

The findings in this research would be highly relevant to cocoa cooperatives and associations, cocoa buyers and exporters in Ivory Coast, government agencies and policymakers, international development organizations, and academic researchers. In addition, the recommendations include expanding digital networks through partnerships, implementing training programs for farmers, and ensuring user-friendly app interfaces. Further research should evaluate improvements in the value chain after application implementation.

Conclusions

Overall, the study demonstrated that tailored mobile-based innovations can benefit cocoa value chain actors by increasing transparency.

INTRODUCTION

Background

Africa has come a long way in recent years, experiencing enormous transformations across various

industries that have significantly impacted both individuals and businesses. From the tech industry to agriculture, African countries have witnessed big developments that have had a profound influence on the lives of many people.

Agriculture, in particular, plays a critical role in every nation's economy, presenting numerous opportunities that one may not anticipate. Fortunately, all African nations benefit from several unique opportunities and advantages the agriculture industry offers. Agriculture is a crucial sector in most emerging countries as it provides food for a growing population, essential goods and raw materials for the manufacturing industry, and a significant link in the input-output value chain.

As (Sandi Johnson, 2023) said, it also offers surplus labor for service sector industries. Agriculture can significantly contribute to a country's economic development and poverty reduction, as it directly links to income generation among the rural poor, whose primary source of income is agricultural production. This, in turn, has a ripple effect on the purchasing power of the urban poor, who depend on agricultural food and tend to spend a significant proportion of their income from non-agricultural sources on agricultural food (Sarris, A, 2001). Therefore, encouraging the expansion of agricultural businesses can go a long way in ending poverty and boosting a country's economic growth and development.

In addition, Agriculture is a cornerstone of the African economy, as 70 percent of Africans depend on it for their livelihood, according to the World Economic Forum (Mamadou Biteye, 2016). The importance of agriculture goes beyond the economy; it also plays a vital role in the survival of families who depend on income from their agricultural production. It is essential to recognize that farmers are the backbone of the agricultural industry. They contribute to food production and people's livelihoods, as highlighted by (Gomez y Paloma, Riesgo, and Louhichi, 2020) in their studies.

Statement of the Problem

Ivory Coast, West Africa's leading cocoa exporter, relies heavily on agriculture to drive its economy. Dedicated farmers work tirelessly to provide high-quality cocoa products to the public. However, the cocoa industry faces a series of significant problems, including a lack of transparency and traceability that directly impacts these hard-working farmers. Despite the size of annual cocoa production, many cocoa farmers in Ivory Coast remain trapped in poverty (Boysen et al., 2023). In addition to transparency issues, these farmers face other obstacles, such as limited access to markets and a scarcity of essential information, which considerably impact their daily lives and financial well-being (Bai et al., 2023). It is, therefore, urgent to find solutions to enable Ivorian cocoa producers to access transparent world markets, fair prices, and the means to improve their livelihoods and bargaining power.

Aim/purpose of the Study

This mixed methods study aims to assess the potential of digital tools to improve transparency and traceability in the cocoa value chain in Ivory Coast and to identify strategies to increase the adoption of these tools among cocoa farmers to solve their challenges. To do this, surveys and interviews will be conducted with cocoa farmers in the Loh Djiboua region, buyers, and experts in Ivory Coast to understand the barriers, enablers, and benefits of using digital technologies such as a mobile application and blockchain to improve market access and incomes for small-scale cocoa farmers.

The research design will use quantitative data from surveys and qualitative data from interviews to provide an overview of the current state of the use of digital tools in the cocoa supply chain and recommendations for increasing adoption. The results of this study will inform strategies for harnessing digital technologies for poverty reduction and the sustainable development of cocoa farming in the Ivory Coast.

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Theoretical Framework

This research study relies on two primary theories – the Diffusion of Innovations Theory, developed by Everett Rogers in 1962, and the Technology Acceptance Model2 (TAM2). TAM2 was developed by Viswanath Venkatesh and Fred D. Davis in 2000 as an extension of the original Technology Acceptance Model (TAM). These frameworks provide useful insights into the acceptance and adoption of new technologies. The Diffusion of Innovations Theory describes how new ideas and technologies are diffused through a social system over time (Rogers, 2010). Rogers argues that innovation, communication channels, time, and the social system influence the diffusion rate.

According to this theory, certain features of an innovation, such as observability, complexity, compatibility, trialability, and relative advantage, determine its adoption rate (LaMorte, 2022). This framework can help evaluate how digital tools are perceived by cocoa farmers and identify the factors that influence their adoption. In contrast, the Technology Acceptance Model 2 (TAM2) suggests that a technology's perceived usefulness and ease of use determine an individual's intention to use it, subsequently influencing actual usage behavior. Thus, farmers are likely to adopt digital tools if they believe that such tools will enhance their performance and are user-friendly. TAM2 provides a model for assessing the potential adoption of mobile apps and blockchain platforms by cocoa farmers (Venkatesh & Davis, 2000).

These two theories offer complementary perspectives on the issue. While the Diffusion of Innovations theory focuses on innovation and communication processes, the TAM2 examines user perceptions and intentions. By integrating these theoretical frameworks, the study aims to evaluate the benefits and challenges of digital technologies for value chain transparency from the viewpoint of Ivorian cocoa farmers. The outcomes of this research can help validate and refine these technology adoption models.

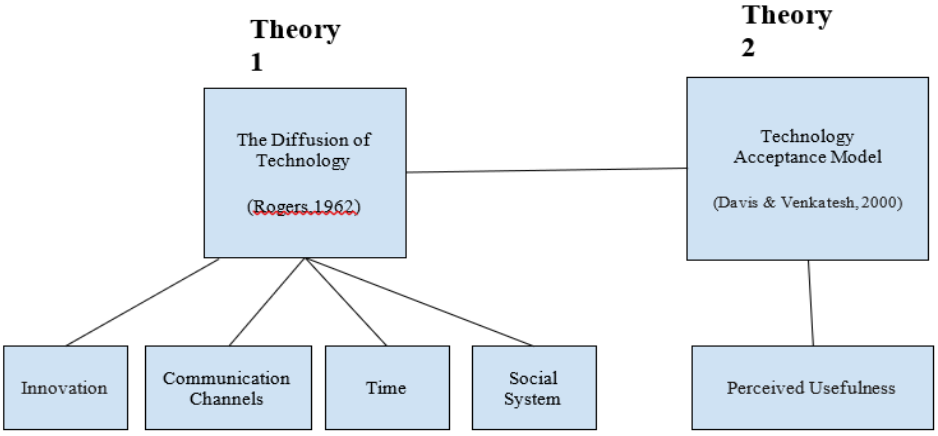


Figure 1.1 – Theoretical Framework Diagram (Author's Own Construct)

Research Questions

Cocoa farming is a cornerstone of Ivory Coast's economy, but small-scale farmers face a number of challenges. It's important to know that digital technologies could improve transparency and traceability and solve farmers' problems in Ivory Coast. This study aims to understand:

Q1. What are the most effective digital tools that can enhance transparency and traceability in the cocoa value chain and help farmers in Ivory Coast improve their livelihoods, and how can their impact be measured?

Q2. What are the main barriers and opportunities for increasing the adoption of digital tools for enhancing transparency and traceability in the cocoa value chain among cocoa farmers in the Ivory Coast, and what

strategies can be implemented to address these barriers and promote the uptake of such tools?

Hypotheses (Quantitative/Mixed Studies Only)

H10. There is no significant difference in income between cocoa farmers who use digital tools and those who do not.

H1a. Cocoa farmers who use digital tools have significantly higher incomes than cocoa farmers who do not use these tools.

H20. There is no significant relationship between perceived usefulness and intention to adopt digital transparency tools among cocoa farmers.

H2a. There is a significant positive relationship between perceived usefulness and intention to adopt digital transparency tools among cocoa farmers.

Nature of the Study

The cocoa industry in Ivory Coast faces significant challenges in enhancing transparency and traceability. To comprehensively examine the issue from multiple perspectives, the study will employ a mixed-methods approach, recommended by (Creswell, 2014) as it facilitates the collection of both qualitative and quantitative data. In particular, the study will adopt Moustakas' model, emphasising the importance of collecting solid qualitative data through interviews and observations (Julia., 2011).

This will enable the study to gain an in-depth understanding of the experiences of cocoa farmers in Ivory Coast and discover the phenomenon's essence from their point of view. The study will follow a sequential exploratory strategy, beginning with qualitative and quantitative data collection through interviews with key stakeholders, including cocoa farmers, cooperatives, buyers, and industry experts. Questionnaires will be developed to learn more about cocoa farmers' and buyers' experiences and readiness to adopt the technology. Additionally, three interview guides will be developed for the expert to gather insights about the cocoa sector in the Ivory Coast. The interview guides aim to understand how the mobile application can be adopted by designing a user-centred application that will solve cocoa farmers' pressing challenges in their daily lives.

By integrating qualitative and quantitative data, the study aims to understand better farmers' difficulties, barriers, and motivations for using digital tools, as well as the perceived benefits of improved supply chain transparency. This approach will also provide statistically representative measures of potential adoption rates. Furthermore, this mixed-methods approach aligns with the study's goal of comprehensively evaluating user-centric solutions. Data analysis will involve thematic and descriptive statistical analysis of the results. Ultimately, this mixed-method study will provide both qualitative and quantitative data to inform a digital transformation strategy for the Ivorian cocoa sector.

Significance of the Study

This study is significant because it examines ways to fix poverty and sustainability problems in the Ivory Coast cocoa industry. Even though this country makes most of the world's cocoa, problems still keep farmers from making enough money to support their families (New York Times, 2022). The study looks at different solutions, like using a mobile application to help farmers and make the cocoa industry more fair. The results will help people make policies and programs that improve the cocoa industry for everyone involved. Moreover, this study also shows how using technology can help farmers in other countries grow and sell their products. If this study works, it could help reduce poverty and ensure everyone is treated fairly.

The study is important because it matches up with some of the goals to make the world a better place, like ensuring everyone has enough to eat and making sure that people can make enough money to support themselves. If the study works in Ivory Coast, it can help other countries as well.

Definition of Key Terms

TAM – Technology Acceptance Method (Marangunić & Granić, 2014)

Delimitations

This study has certain limitations and is restricted to specific parameters. It focuses on cocoa farmers, buyers, and experts operating in the context of Ivory Coast, and the results may not apply to other countries (Ruf et al., 2020). In addition, the study focuses on a particular mobile app-based solution and needs to evaluate the full range of digital tools available to the cocoa industry (Centobelli et al., 2021). In addition, interviews will only be conducted with farmers in the Loh Djiboua region rather than on a national scale.

Summary

In Ivory Coast, cocoa farming is a crucial part of the economy, but farmers face several challenges. To address this, a mixed-methods study is being conducted to explore how digital solutions like mobile apps can help improve traceability and enable Ivorian cocoa farmers to earn fair prices and increase their incomes. To gain insights into the farmers' needs, obstacles, and optimal strategies, the study will employ a combination of interviews with farmers and experts, as well as surveys and interview guides. This comprehensive approach will provide qualitative information and statistical measurements to understand the issues better.

The study aims to inform policies and interventions to help reduce poverty, promote climate resilience, and ensure global human rights due diligence in agricultural supply chains. Through this research, the Ivorian cocoa sector can develop a digital transformation strategy that benefits both farmers and the economy.

Concepts

A- Transparency and Traceability

It is necessary to understand the two concepts when it comes to using digital tools to enhance transparency and traceability. Transparency is defined as a public value adopted by society to fight corruption and is synonymous with open decision-making by governments and non-profit organizations (Bahar Memarian, 2023). It is considered a complex tool for good governance in programs, policies, organizations, and nations.

On the other hand, traceability refers to the completeness of the information about every step in a process chain (Islam & Cullen, 2021). Blockchain technology and mobile applications have been essential in enhancing the transparency and traceability of certain products, minimizing fraud and errors, improving inventory management, reducing courier costs, and decreasing waste and delays (Centobelli et al., 2021). Mobile apps are utilized on devices to track the movement of items along the value chain. Each recorded event or transaction is time-stamped, encrypted, and uploaded to the blockchain, resulting in an immutable and auditable record of the product's journey (Akhtaruzzaman Khan et al., 2022).

B- Value Chain

The value chain is another critical concept regarding digital tools for enhancing transparency and traceability. The value chain is a process through which we can look up every step, from procurement to the

end-users of goods or services (Jones et al., 2019). As a result, the cocoa value chain includes all operations related to producing, processing, distributing, and consuming cocoa beans and cocoa-based products. Farmers, cooperatives, merchants, processors, manufacturers, distributors, and retailers play essential roles in the cocoa value chain.

C- Barriers

Despite the advent of digital tools in our century, barriers still need to be overcome to increase the adoption of digital tools in the cocoa value chain. The barriers identified are:

C.1 – Limited access to technology

Limited access to technology is a barrier because inadequate infrastructure, such as intermittent Internet access and poor network coverage, limits the use of digital platforms and data exchange in cocoa-producing regions (Salazar et al., 2023).

C.2 – Reluctance to change in technology adoption

Another barrier to overcome is a reluctance to change in technology adoption. Many actors in the cocoa value chain may be hesitant to embrace digital solutions due to a lack of information, distrust, or fear of upsetting present procedures (Tsai et al., 2019).

D- Enablers

Nevertheless, some enablers can be found by addressing the barriers that can be implemented to increase the adoption of digital tools in improving transparency and traceability in the cocoa value chain: access to technology, which involves giving cocoa farmers, cooperatives, and other value chain actors access to cell phones, tablets, PCs, and Internet connectivity; capacity building and training, which includes training on how to use digital tools for greater efficiency; and finally, rewards and incentives, which include financial incentives, access to markets, or recognition for sustainable practices and early adoption.

E- Theories (Diffusion of Innovation and TAM2)

Several theories have been studied to understand the behavior and habits of people about adopting new technologies and make the process successful and sustainable.

E.1- The Diffusion of Innovation Theory

The Diffusion of Innovation theory, developed by Everett Moore Rogers, a Professor of Communication, focuses on adopting technology in higher education and educational contexts (LaMorte, 2022). Rogers introduced this theory in his book “Diffusion of Innovation” in 1962, providing a comprehensive framework for examining the factors influencing the acceptance and spread of innovations.

According to this theory, when a new habit or product is introduced, it spreads among individuals within a social system. The diffusion of innovation theory applies the diffusion of innovation law, which compares the spread of new ideas or behaviors to how a drop of food dye diffuses through water in a glass (Johnson, 2022). The diffusion of innovation occurs on both personal and social levels, with individuals assessing the impact of innovation using the diffusion of innovation model and innovation spreading from a small number of users to widespread adoption across a population or society (Johnson, 2022). In his book, Everett defines adoption as the decision to fully use an innovation as the best course of action and rejection as the decision not to adopt an innovation. He also defines diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2010). This concept

highlights the importance of innovation, communication channels, time, and the social system in diffusion.

Rogers' theory has been widely explored and applied in various studies. For example, (Lovejoy et al., 2009) conducted a study titled "Advancing the Practice of Online Psychotherapy: An Application of Rogers' Diffusion of Innovations Theory." This research examines the implementation of clinical innovations within the diffusion of innovations theory framework. This theory's significance lies in demonstrating the relevance of applying Rogers' theory in understanding the diffusion of renewable energy technologies and comprehending the diffusion process within his theoretical framework. By utilizing Rogers' theory, we aim to incorporate key factors that can facilitate the adoption of a mobile application by farmers in the cocoa value chain in the Ivory Coast, as well as study their behaviors with such technology. We will be looking at all the theory components, such as innovation, communication channels, time, and the social system.

E.2- Technology Acceptance Model 2 (TAM2)

A relevant concept by Venkatesh and Davis focuses on perceived usefulness, usage intentions, and the influence of social factors and cognitive instrumental processes. They developed an extended model, "TAM2," which builds upon the Technology Acceptance Model (TAM) (Maureen Sullivan, 2016). Initially, TAM (First version) aimed to understand the mechanisms underlying technology acceptance and provide a theoretical explanation for effective technology deployment. It has become a key model in predicting human behavior related to technology acceptance or rejection (Marangunić & Granić, 2014).

However, recognizing the limitations of TAM, Venkatesh and Davis developed TAM2 to explore additional determinants of perceived usefulness. TAM2 introduces three interconnected social forms: subjective norm, voluntariness, and image. These forms help determine an individual's acceptance or rejection of a new system. Additionally, cognitive factors of perceived usefulness in TAM2 are defined as perceived ease of use, output, output quality, and work relevance (Marangunić & Granić, 2014). TAM2 is a valuable asset for the research paper because it has undergone extensive validation and has been widely used in empirical research, such as the study by (Sharifzadeh et al., 2017) about "Predicting adoption of biological control among Iranian rice farmers: An application of the extended technology acceptance model (TAM2)."

With their demonstrated predictive power in various contexts and technologies, these models can be leveraged to make meaningful predictions about the acceptance and adoption of the app being considered for adoption by farmers. For this research paper, we will be looking at only one component of TAM2, which is perceived usefulness. Perceived usefulness refers to how much someone believes a technology or system will benefit them (Davis, 1989).

F- Key Debates and Controversies

One of the debates surrounding Rogers' theory of "diffusion of innovation" revolves around the argument that diffusion may exhibit non-linear patterns that deviate from the expected linear trajectory. This non-linear diffusion is characterized by sudden fluctuations in adoption rates and the existence of multiple diffusion paths. Adoption rates, in particular, can experience sudden peaks or bursts when innovations are rapidly accepted due to external factors such as significant endorsements, marketing initiatives, or changes in public opinion. These peaks raise doubts about the classic diffusion model's projected progressive, linear trend.

To address these issues, scholars have developed alternative models that provide a more realistic understanding of the nonlinear dynamics of diffusion. The Bass Diffusion Model is one such model that considers both the inherent appeal of the invention and the role of social contagion effects in promoting adoption. The Bass Diffusion Model more effectively reflects the complexities of nonlinear diffusion by incorporating these factors (Bertotti et al., 2016). The discussion about the differences in the applicability of

the TAM and TAM2 models highlights the significance of cultural context in influencing individuals' attitudes and behaviors toward technology adoption.

Critics argue that these models, which were largely developed and tested in Western cultures, may not adequately capture the intricacies and nuances of non-Western cultural technology acceptance (Malatji et al., 2020). Cultural differences comprise various elements, including values, beliefs, social norms, and cognitive processes, all affecting people's decision-making processes. Various cultures may prioritize different aspects when assessing technology's usefulness and ease of use and the social pressures that affect its acceptance or rejection (Malatji et al., 2020).

Critics propose the need for a more culturally sensitive approach to account for the diversity of cultural values, attitudes, and behaviors. They suggest creating modifications or extensions to the TAM and TAM2 models that include culture-specific elements and dimensions relevant to non-Western contexts.

Summary

This chapter provides an overview of the key concepts related to the research topic. The literature review investigated how blockchain and mobile applications can increase transparency and traceability in the cocoa industry, reducing the likelihood of fraud and errors (Centobelli et al., 2021). It also defined the cocoa value chain as the process encompassing cocoa goods and services from procurement to the end-users (Jones et al., 2019). The study identified challenges to technology adoption, such as lack of information, distrust, and fear of change, while access and training were recognized as enablers (Tsai et al., 2019).

In addition, two theoretical frameworks – Davis and Venkatesh's TAM2 model and Rogers' Diffusion of Innovation Theory – provided insights into farmer behavior and strategies for encouraging them to adopt new technologies (LaMorte, 2022). By reviewing these concepts, models, barriers, and enablers, the literature presents a fundamental understanding of how mobile applications can revolutionize the cocoa value chain by augmenting traceability and empowering Ivorian cocoa farmers.

Research questions

The research questions are as follows:

- What are the most effective digital tools for improving transparency and traceability in the cocoa value chain, and how can their impact be measured to help Ivorian cocoa farmers improve their livelihoods?
- What are the main barriers and opportunities for increasing the adoption of digital tools that improve transparency and traceability in the cocoa value chain among cocoa farmers in Ivory Coast, and what strategies can be implemented to remove these barriers and promote the adoption of these tools?

This chapter provides a full description of the research methodology, including the research design, participants, instruments, data collection, and analysis techniques that will be used to answer the research questions. In addition, ethical considerations are briefly discussed.

RESEARCH METHODS AND DESIGN(S)

The research method chosen for this study is mixed-methods-based research. It enables more robust research to be carried out. The mixed method provides richer information about the phenomenon under study, capturing information that would have been missed if a single research model had been used. It broadens the body of knowledge and generates more questions of interest for future studies, which can address a wider range of research questions because the researcher is not restricted to a single research model (Caruth,

2013). In particular, the study will adopt Moustakas' model, which emphasizes the importance of collecting solid qualitative data through methods such as interviews and observations (Julia E., 2011).

For this research paper, we aim to assess the potential of digital tools to enhance the transparency and traceability of the cocoa value chain in Ivory Coast. Using this method will help in building and testing theories. In our literature review, we have discussed two theories, such as TAM2 (Venkatesh & Davis, 2000), that will help us understand how we can promote the adoption of digital tools in the cocoa value chain and understand the behavior of cocoa farmers and buyers. The research paper will require interviews and surveys to understand the problem and the approach better.

A sequential exploratory strategy will be employed to gather relevant data for this study. This will involve qualitative and quantitative data collection through interviews with key stakeholders such as cocoa farmers, cooperatives, buyers, and industry experts. Questionnaires will be used to understand better the experiences and readiness of cocoa farmers and buyers to adopt new technology. In addition, three interview guides will be designed to gain insights into the cocoa sector in the Ivory Coast. The interview guides will be geared towards understanding how the mobile application can be adopted by designing a user-centred application that will solve cocoa farmers' pressing challenges in their daily lives. By integrating qualitative and quantitative data, the study aims to understand farmers' challenges, barriers, and motivations to use digital tools, as well as the perceived benefits of improved supply chain transparency.

Population

This study focuses on the smallholder cocoa farmers in Ivory Coast, who face significant challenges related to poverty, market access, and sustainability (New York Times, 2022). According to (Ruf et al., 2020), there are between 400,000 and 450,000 officially certified cocoa farmers in the country. The experiences and perceptions of these farmers are crucial for understanding the practical implications and potential adoption of digital transparency tools in the cocoa industry. Secondary populations that will be considered in this study include cocoa cooperatives, buyers/exporters, and industry experts in Ivory Coast.

Cooperatives offer support services to farmers and facilitate trade, and their perspectives can help to identify farmer motivations and challenges. Buyers and exporters connected to international markets can provide insights into consumer demand for traceability and how technology could be integrated into supply chain management. Experts such as agricultural professionals and government officials will contribute high-level knowledge of the cocoa sector, regulations, and technology ecosystems. By taking a holistic approach and considering the perspectives of all these stakeholders, this study aims to provide a comprehensive assessment of digital tools across Ivory Coast's cocoa value chain. This will help evaluate technology's impact and develop strategies tailored to the Ivorian context.

Sample

To gather data for this study, we will conduct surveys and interviews with 12 cocoa farmers selected through stratified random sampling from the Loh Djiboua region in Ivory Coast. Since the estimated population of cocoa farms in the Ivory Coast is over 400,000 (Ruf et al., 2020), a sample size of 12 will provide enough statistical power for quantitative analyses based on similar adoption studies. In addition, surveys and interviews will be used to interact with five buyers/exporters/cooperatives and three experts who were purposively selected for their knowledge and relevance to the research topic. These sample sizes are appropriate for reaching data saturation in qualitative research, given the narrow focus of this study (Vasileiou et al., 2018).

To recruit farmers, we will reach out to cooperatives and industry associations. We will use snowball sampling to identify buyers and experts. This mixed methods sampling approach will allow us to obtain

quantitative data that is statistically representative of the wider cocoa farmer population while also accessing information-rich qualitative sources across the value chain. The samples complement each other to facilitate an expansive analysis of digital transparency and traceability tools from multiple stakeholder perspectives.

Materials/Instruments

For the farmer questionnaire, a set of 15 questions will be used to gather data on various aspects such as demographics, gender, age, education, sales process, income, farm size, technology use, perceived usefulness, and other adoption factors within the framework of TAM 2 and Roger's theory. The qualitative data will be collected through semi-structured interviews, following a specific protocol designed to explore the outlook for the cocoa industry in Ivory Coast.

Limitations

The sample size of the study, consisting of 12 farmers, 5 buyers, and 3 experts, is relatively small, which means that the findings cannot be generalized to the entire Ivorian cocoa industry. However, the study aims to provide an in-depth exploration of the issues at hand.

To reduce response bias among participants, the researcher will ensure anonymity and use neutral questioning techniques. This will help ensure that participants provide honest answers rather than what they think the researchers want to hear.

Language barriers may pose challenges during interviews, leading to miscommunications or misunderstandings. To mitigate this limitation, local interpreters will be used to facilitate communication between participants and researchers.

Lastly, technical issues, such as poor connectivity during remote interviews, could disrupt discussions. To address this, contingency planning for connectivity problems will be in place to ensure smooth communication and avoid any disruptions.

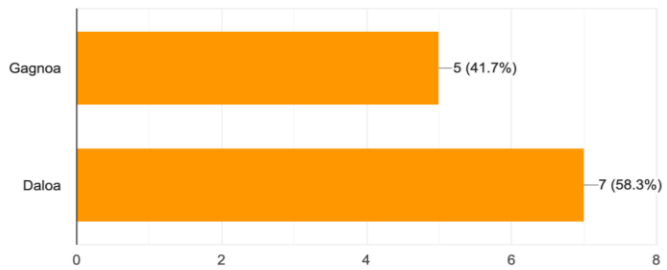
FINDINGS

Results

Farmers

The following results were obtained from interviews conducted with cocoa farmers using a quantitative research method. Twelve farmers who were willing to participate responded to a set of questions aimed at advancing this research study. The interviews provided numerical data and statistical insights into the views and experiences of farmers in the Ivorian cocoa sector. The findings from these structured interviews with farmers are presented below:

Figure 4.1.1 In which city are you currently located in the Lôh Djiboua region?



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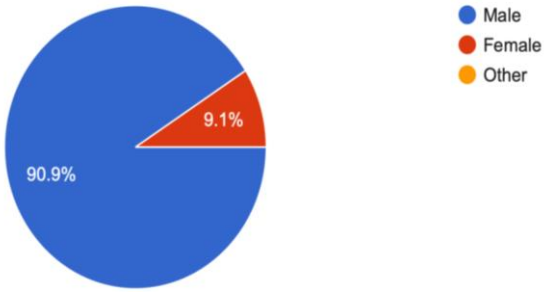
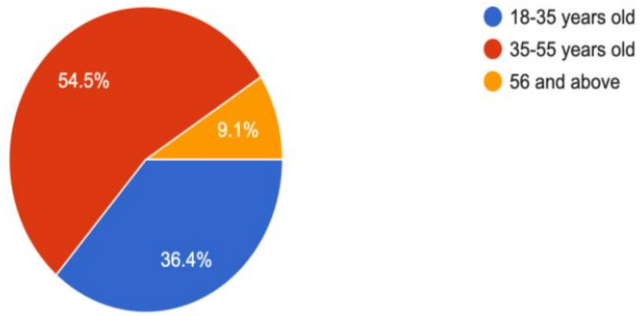
Of the 12 Ivorian cocoa farmers who participated in interviews for this study, 5 hailed from the city of Gagnoa, representing 41.7 percent of the sample, while the remaining 7 farmers, making up 58.3 percent, called the city of Daloa their home.

Figure 4.1.2 What's your gender?



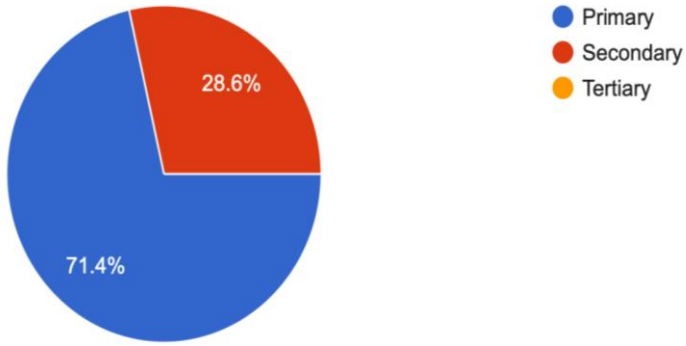
90.9 percent of respondents were men and 9.1 percent were women.

Figure 4.1.3 How old are you?



54.5 percent of respondents were aged between 35 and 55, 36.4 percent were aged between 18 and 35, and 9.1 percent were aged 56 and over.

Figure 4.1.4 What is your level of education?



71.4 percent of respondents have primary education and 26.6 percent have secondary education. None of them have tertiary education.

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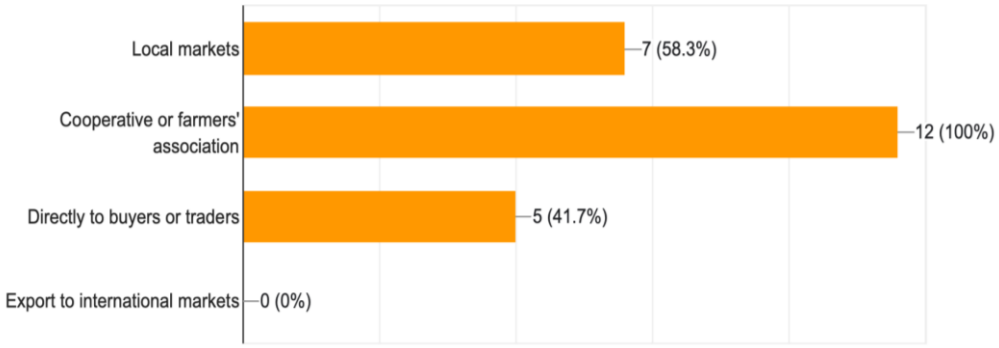
Figure 4.1.5 Which channels do you primarily use to sell your cocoa?

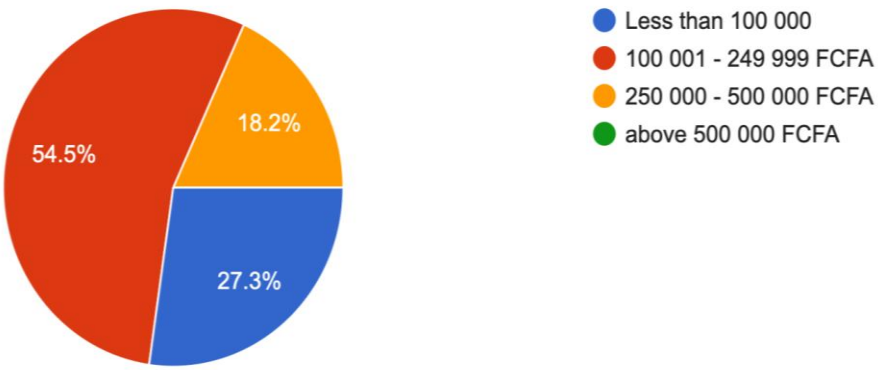


The interviews revealed that local markets are an important sales channel for the surveyed farmers, with 58.3 percent indicating that they use these markets to sell their cocoa. All (100 percent) of the respondents reported utilizing cooperatives or farmer associations to sell their cocoa crops. Additionally, 41.7 percent of the farmers interviewed sell their cocoa to buyers or traders that likely export the raw cocoa beans.

Figure 4.1.6 How frequently do you sell your cocoa?

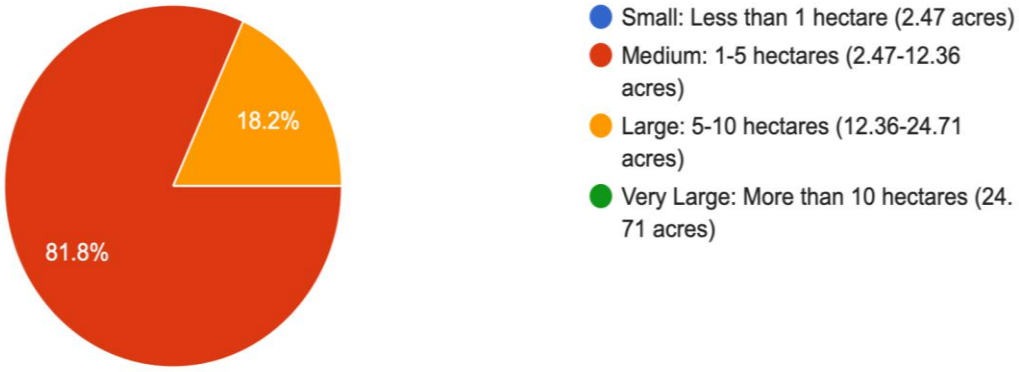
100 percent of the farmers sell their cocoa right after each harvest.

Figure 4.1.7 What is your typical revenue after selling your cocoa?



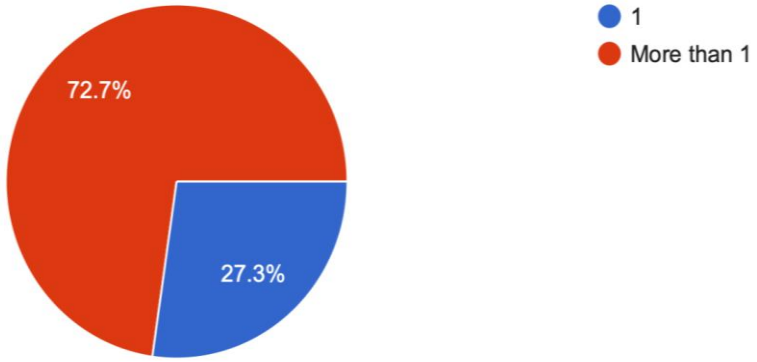
54.5 percent of farmers earn between 100,001 and 249,999 Fcfa after selling their cocoa, 27.3 percent earn less than 100,000, and 18.2 percent earn between 250,000 and 500,000 Fcfa.

Figure 4.1.8 What is the size of your farm?



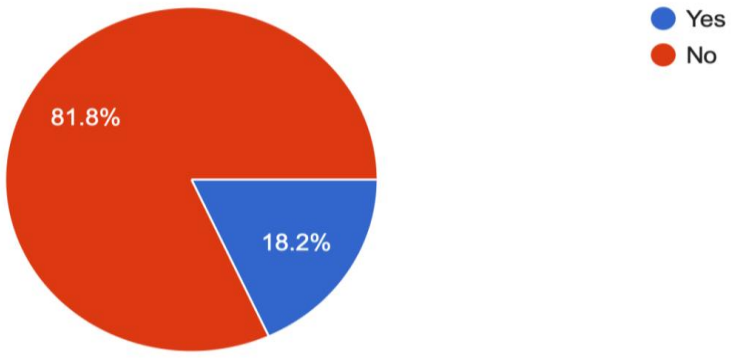
81.8 percent of farmers have medium-sized farms, between 1 and 5 hectares, and 18.2 percent between 5 and 10 hectares.

Figure 4.1.9 How many smartphones do you and your family own?



72.7 percent of farmers have more than one smartphone, and 27.3 percent have just one.

Figure 4.1.10 Have you ever used any digital tools or mobile applications to assist you in your cocoa farming activities?



81.8 percent of cocoa farmers have never used a digital tool or mobile application to help them in their cocoa farming activities, and 18.2 percent have.

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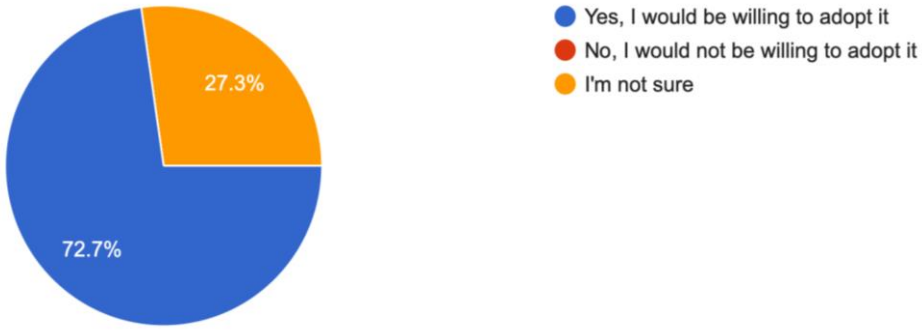
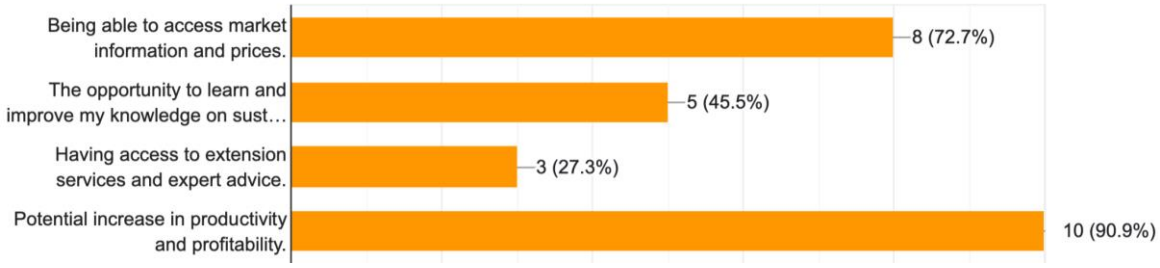
Figure 4.1.11 Would you be willing to adopt a mobile application that provides information and guidance on best farming practices and market prices and connects you with potential buyers?



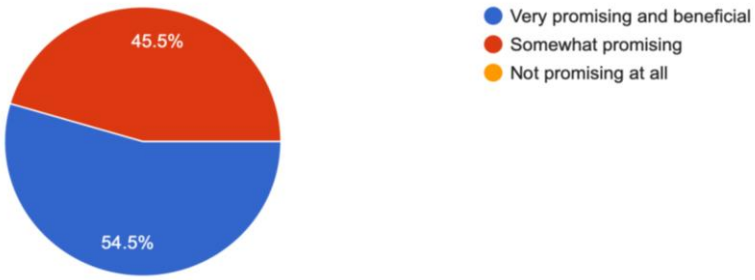
72.7 percent of cocoa farmers responded that they would be willing to adopt the mobile application, while 27.3 percent were unsure whether they would or not.

Figure 4.1.12 What factors would motivate you to adopt a mobile application for your cocoa farming activities?



The highest percentage of cocoa farmers responded that "the potential increase in productivity and profitability" would motivate them to adopt a mobile application for their cocoa farming. (90.9 percent).

Figure 4.1.13 What are your views on the potential of digital tools to enhance transparency and traceability in the cocoa value chain?



54.5 percent of the farmers find the digital tool promising and beneficial, and 45.5 percent find it somewhat promising.

Buyers

The following were obtained from interviews conducted with cocoa buyers using a quantitative research method. Five cocoa buyers (including brokers) who were willing to participate responded to a set of

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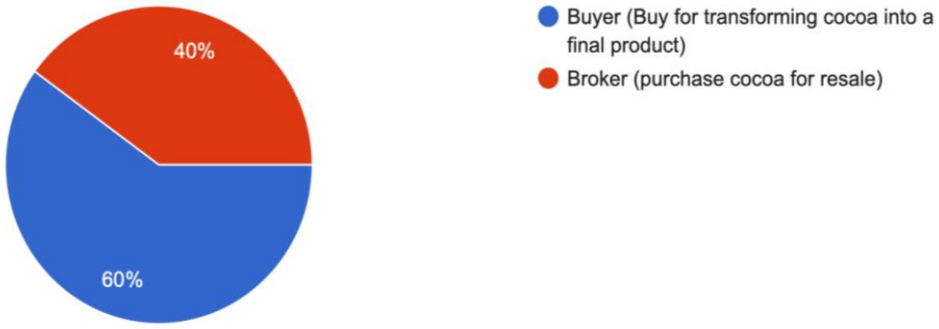
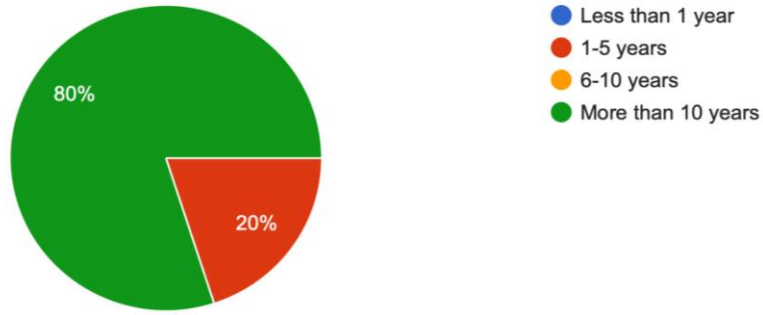
questions aimed at advancing this research study.

Figure 4.2.1 You are a



Of the 5 cocoa buyers, 60 percent were direct buyers, and 40 percent were brokers (they buy cocoa for resale).

Figure 4.2.2 How long have you been involved in the cocoa buying/trading business?

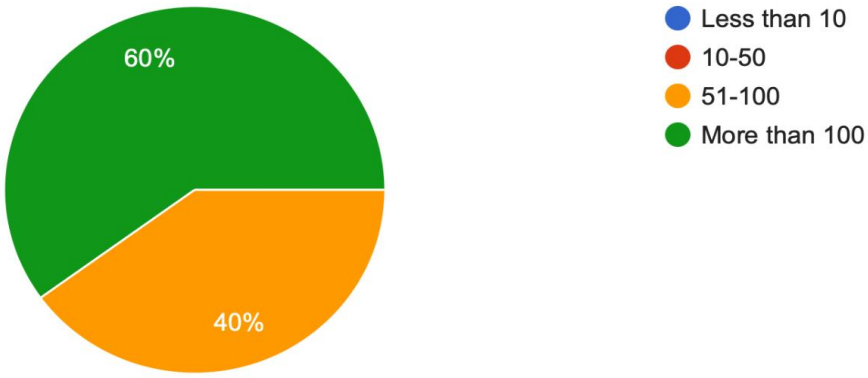


80 percent of buyers have more than 10 years of experience, and another 20 percent have between 1 and 5 years of experience in the cocoa sector.

Figure 4.2.3 What geographical areas or regions do you primarily source cocoa from?

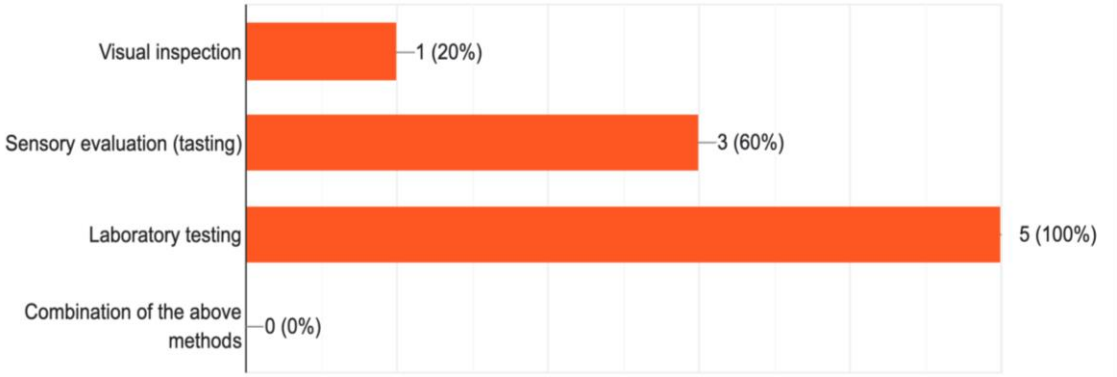
The north (80 percent), east (80 percent) and south (80 percent) are where buyers get most of their products, and the west (60 percent).

Figure 4.2.4 On average, how many cocoa suppliers do you engage with annually?



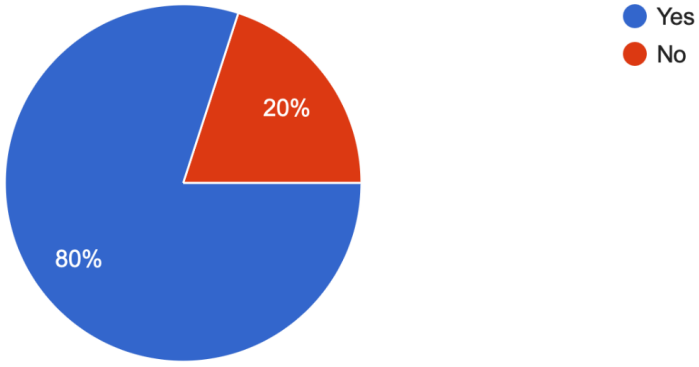
60 percent of respondents have relationships with more than 100 cocoa suppliers yearly, and 40percent between 51 and 100 a year.

Figure 4.2.5 How do you currently assess the quality of cocoa beans during the sourcing process?



100 percent of respondents evaluate cocoa by laboratory tests, 60 percent by sensory evaluation, and 20 percent by visual inspection.

Figure 4.2.6 Question: Have you encountered challenges related to transparency and traceability in the cocoa value chain?



80 percent of buyers encounter difficulties related to traceability and transparency in their activities, and 20 percent do not. (We will discuss more about the challenges in the next chapter)

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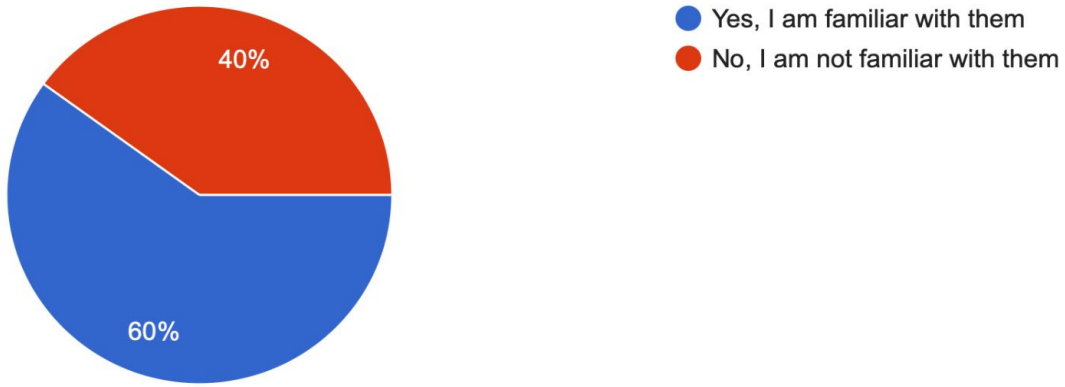
Figure 4.2.7 Question: How important is it for you to have transparency and traceability in the cocoa beans you source?

100 percent of buyers consider the transparency and traceability of the cocoa beans they buy to be important.

Figure 4.2.8 Question: Are you familiar with digital tools or platforms that enhance transparency and traceability in the cocoa value chain?



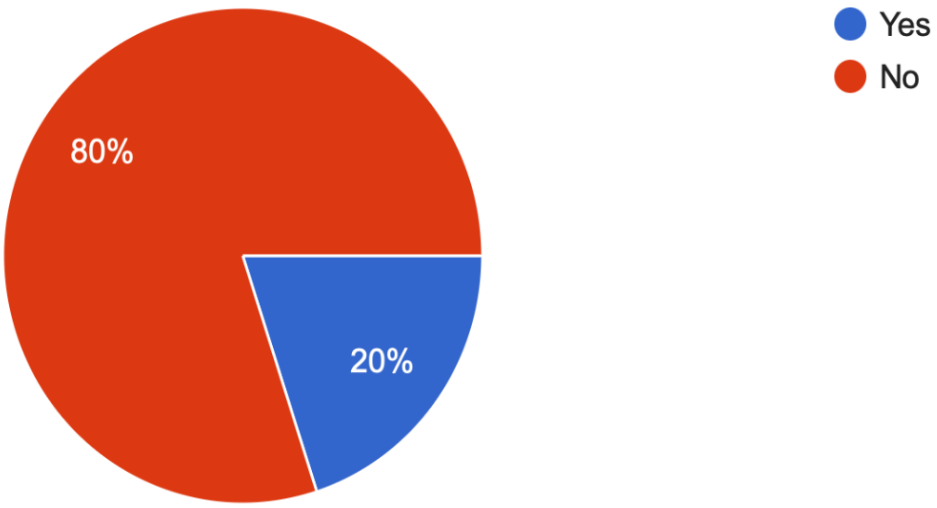
60 percent of buyers are aware of digital tools or platforms that improve transparency and traceability in the cocoa value chain, and 40 percent are not.

Figure 4.2.9 Question: What factors motivate you to adopt a digital tool for your cocoa buying/trading business?

“Access to new markets” and” improved transparency and traceability” received 100 percent of responses,

while “Improved efficiency and productivity” and “Cost savings” received 80 percent.

Figure 4.2.10 Question: Are you using digital tools or platforms to facilitate your cocoa buying/trading operations?



80 percent of buyers use digital tools to facilitate their cocoa operations, and 20 percent do not.

Experts

To obtain expert insights into enhancing the Ivorian cocoa value chain, we conducted qualitative interviews with three professionals, each providing unique perspectives.

The first expert boasts decades of experience in the cocoa value chain industry. The Expert’s invaluable contribution to the study involved elucidating the structure and challenges of the Ivory Coast cocoa value chain. The expert helped in grasping the critical aspects of transparency and traceability within the cocoa value chain and identifying and comprehending the key stakeholders engaged in the cocoa value chain, along with their respective responsibilities and challenges. Furthermore, this expert provided us with a comprehensive understanding of the evolving landscape of the cocoa value chain and its future prospects.

The second expert works with a well-known company in the cocoa sector, and the interview’s expert contributed by sharing an insight into the potential of digital technologies, in particular, a mobile application, to boost transparency and traceability in the cocoa value chain. The third expert works for a digital solutions company. Drawing on their expertise, this research combines real-world knowledge with cutting-edge innovations to envision an inclusive and prosperous future for cocoa in Ivory Coast. This expert helped explore the potential of a mobile application and other digital technologies to improve transparency and traceability throughout the cocoa value chain. The expert also clarified the precise functionalities and features required for a mobile application to promote transparency and traceability, as well as to identify the obstacles and limitations associated with implementing a mobile application within the cocoa value chain.

EVALUATION OF FINDINGS

Given the numerous challenges that farmers face, it’s essential to recognize that the ever-evolving field of

technology has given rise to a valuable ally for their farming endeavors: digital tools. In this research paper, we have examined the importance of these digital tools and found that their relevance to modern farming practices is undeniable. Farmers were primarily interviewed to gain deeper insights into their challenges. Some continue living in poor conditions even after selling their products.

Moreover, the interviews aimed to assess how potential digital tools could improve their livelihoods by enhancing the transparency and traceability of the cocoa value chain. Among all the technologies identified to address the real challenges farmers face, mobile application has been selected as an efficient tool that farmers can easily use to sell their products. As mentioned by (Akhtaruzzaman Khan et al.,2022), mobile applications are utilized on devices to track the movement of items along the value chain. Each recorded event or transaction is time-stamped, encrypted, and uploaded to the blockchain, resulting in an immutable and auditable record of the product's journey. The interpretation of our results will follow a structured sequence, allowing us to delve deeper into the collected data and their relevance to this research study.

To begin with, the data collected from farmers will be analyzed using thematic and descriptive statistics. Next, the data collected from buyers will be subjected to thematic analysis. This approach will facilitate a comprehensive exploration of our dataset and its applicability in the context of our research.

1- Farmers

We conducted a qualitative and quantitative study with twelve farmers in the Loh Djiboua region who agreed to be interviewed and share most of the information regarding their activities. Daloa and Gagnoa were chosen as the sample size for this study, as they are located in the Loh Djiboua region in Ivory Coast. The respondents were mostly male (11 out of 12) aged 18-55 years old with secondary or primary education. Speaking with farmers confirmed that the education level has some influence on the way they might adopt the technology since some of them did not attend any tertiary education. The education level also significantly impacts their farming practices and how they sell their products, as they can be scammed due to their lack of education. In addition, the education level can be a barrier to adopting a mobile application. Since the population is relatively young, there is still a chance that they may be willing to adopt such technology in their farming processes.

During the interviews, farmers mentioned that it is important for them to be educated on the technology first before starting to use it, which can increase their perceived usefulness. The results are consistent with the study of (Mishra, 2010), which found that the level of education can be a real problem when it comes to adopting a new technology that the social system is unfamiliar with, and only 2 out of 12 farmers have responded that they have ever used a digital tool in their farming activities. Regarding the channels they use to sell their cocoa primarily, 100percent of them reported that they use cooperatives or farming associations for selling their cocoa. 58.3percent indicated that they use local markets to sell their cocoa, and 41.7percent of the farmers interviewed sell their cocoa directly to buyers or traders who likely export the raw cocoa beans.

1.1- Cocoa journey (Farmers – Cooperatives)

Cooperatives play a huge role in supporting farmers' production. Cooperatives are groups of farmers who come together to manage and sell their cocoa (Calkins & Ngo, 2010). The cocoa journey is long since farmers must undergo a long process to have good cocoa. Farmers manually harvest the cocoa with some machetes or other tools when the cocoa pods are ready. For developed farms, farmers have access to technology that helps harvest the cocoa, but for this particular study, the farmers interviewed still use traditional ways of harvesting. After harvesting, farmers open the cocoa pods to access the cocoa beans, which is often done on-site at the cocoa farm. Then, after that process is finished, the freshly harvested cocoa beans are placed in shallow containers or boxes and left to ferment for several days. Farmers noted

that fermentation is a crucial step in developing cocoa flavor.

After several days of fermentation, the drying process starts. The cocoa beans are spread out to dry in the sun. They mentioned that drying helps reduce the moisture content and preserve the beans for storage and transport. Once dried, cocoa beans are usually bagged and stored in a suitable place, which can be on the farm or in a communal storage facility. Farmers mentioned that proper storage is essential to prevent mold or insect infestations. Once that process is done, farmers, individually or in groups, transport their bags of dried cocoa beans to the local cooperative's collection point. This can involve walking, bicycling, or using other means of transportation. Most of the farmers interviewed mentioned that since some of their farms are far away from the villages or city, they walk and use bicycles to transport the cocoa to the appropriate location. The cocoa beans are weighed at the cooperative and undergo a quality check.

The cooperative assesses the quality of the beans and rejects those that do not meet the required standards, which becomes another problem for farmers since sometimes most of their cocoa is rejected after they put in so much effort to produce the cocoa beans. After the quality check, the cooperative pools the cocoa beans from various farmers and groups. They aggregate the beans into larger quantities, making negotiating with buyers and accessing larger markets easier. After that process is done, the cooperative takes on the responsibility of marketing and selling the pooled cocoa beans on behalf of its members. They may negotiate with exporters, processors, or chocolate manufacturers. After selling the cocoa, the cooperative distributes the proceeds to individual farmers. The payment is based on the quantity and quality of beans each farmer contributes. With the data collected, 54.5 percent of farmers are earning between 100,001 and 249,999 Fcfa after selling their cocoa, 27.3 percent earn less than 100,000 fcfa, and 18.2 percent earn between 250,000 and 500,000 Fcfa, and 81.8 percent of farmers have medium-sized farms, between 1 and 5 hectares, and 18.2 percent between 5 and 10 hectares. The farm's size can generally impact the farmer's income since the farmer's remuneration is linked to the number of kilograms sold or handed over to the cooperatives.

Even if some farmers are paid on time, some of them have indicated that there are sometimes delays in payment, which can affect their activities as well as their families. Some of them have indicated that they cannot enrol their children in school because of these delays. Digital tools such as mobile application can help farmers get paid on time and without too much stress after handing over their produce to the cooperatives. Although payments have been modernized, farmers still carry papers with them when they go to get paid, which is becoming a problem that needs to be remedied. This problem confirms once again that only technology, such as a mobile application, can help solve this problem farmers face with their payments and paperwork.

In addition to these particular challenges, farmers mentioned other difficulties they are facing. Climate change, financing, and lack of roads are just some of the challenges they face during their farming activities. Climate change is one of the biggest challenges facing farmers, as it is unpredictable and causes significant damage to their crops. Erratic weather conditions, prolonged droughts, and extreme rainfall can lead to lower yields, affecting their livelihoods. Financing is another major obstacle since many farmers struggle to access affordable credit or loans to invest in their farms, buy the necessary equipment, or expand their activities.

This financial constraint limits their ability to adopt modern, more efficient farming practices. In addition, the lack of adequate roads hampers the transport of inputs and produce. Poor road infrastructure can delay getting their produce to market, resulting in deterioration or loss of quality. It also limits their access to essential resources and services. These elements can act as barriers to innovation adoption and diffusion, one of Everett Moore Rogers' elements of innovation diffusion mentioned in our literature review (Johnson, 2022).

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Access to smartphones is one of the key points of this research paper. 72.7 percent of farmers responded that they own more than one smartphone, and 27.3 percent have only one in their family. Smartphones play an essential role in the agricultural sector. They are used by most farmers, who see network technology as the most effective way of improving their knowledge and understanding of modern agricultural technologies (Kumar, R. 2023). To access the mobile application, farmers need to have access to smartphones, which will help them in their daily operations. 72.7 percent of cocoa farmers responded that they would be willing to adopt the mobile application, while 27.3 percent were unsure whether they would or not. Farmers' reluctance to decide whether or not to adopt it may be linked to the fact that they don't own a smartphone or that the ones they use aren't sophisticated enough to meet their needs, which represents one of the limitations of this research study. Farmers also mentioned the Internet connectivity problem as one of the challenges they face in their various localities, given that most villages are not yet well covered. Lack of infrastructure can be an obstacle to adopting the technology, as it cannot function without an Internet connection. Despite the myriad challenges facing farmers, the receptiveness rate to adopt the technology has been particularly high. Farmers expressed strong interest in the mobile application, citing several factors. An impressive 90.9 percent of cocoa farmers said the prospect of increased productivity and profitability was a strong motivation for adopting a mobile application.

In addition, 72 percent of those interviewed said they were ready to adopt the technology because it provided them with valuable market information and price data. In addition, 45.5 percent of farmers expressed a desire to embrace innovation as a means of extending their knowledge and skills in sustainable farming practices. In addition, 27.3 percent of respondents identified another key factor: the aspiration to access extension services and expert advice. Such access would enable them to make informed decisions and optimize their farming techniques, illustrating their desire to improve their farming practices continually. And 54.5 percent of the farmers find the digital tool promising and beneficial, and 45.5 percent find it somewhat promising.

The results of the interviews with cocoa farmers in Ivory Coast provided important insights that directly address the research problem outlined at the start of this study. This research aimed to understand the challenges faced by cocoa farmers and assess how digital tools, such as a mobile application, could help improve the transparency and efficiency of the cocoa supply chain. The farmer's interviews reveal several challenges that align with the purpose of this study, such as lack of access to information, delays in payment with the cooperatives, illiteracy because most of them do not have tertiary education and sometimes get scammed, and other challenges they face when it comes to transport the cocoa beans from their farms to the cooperatives or city for selling. Despite the many challenges they confront in their farming activities, it is clear that lack of transparency is a fundamental problem.

The interviews conducted also highlighted the prevalence of this problem. Furthermore, regarding adoption potential, the results clearly indicate that farmers are very willing to adopt a mobile application, with 72.7 percent declaring themselves ready to adopt such technology. This high receptiveness is attributed to farmers' perception of the mobile application as a means of improving productivity, increasing profitability, accessing valuable market information, and benefiting from expert agricultural advice. Consequently, the data gathered from these farmer interviews offers essential corroborative evidence, suggesting that a mobile application has the potential to improve transparency issues within the cocoa supply chain. These results align with the purpose and research questions initially defined for the study.

2- Buyers

We conducted a quantitative and qualitative study with five buyers who agreed to answer some of the prepared questions to share important details about their purchasing processes, their experience in the sector, and any other information they might have to help us proceed with this research study. 5 buyers agreed to

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take part in the interviews, all from different companies and associations. 4 out of 5 buyers had been involved in the cocoa industry for more than 10 years, which was beneficial for this research study, as they were able to make a perfect contribution thanks to their knowledge of the industry. We identified common patterns in their purchasing behavior and realized that the South, East, and North are the regions where most buyers source their cocoa. The western region received 60 percent of respondents, probably due to the small number of cocoa farmers living in this region. In addition, 60 percent of cocoa buyers engage with more than 100 cocoa farmers annually, and only 40 percent engage with fewer farmers (51-100) yearly. Their purchasing strategies vary as they engage with different types of cooperatives or farmers nationwide. No specific region was identified while analyzing the data provided by cocoa buyers.

In addition, for cocoa to be eligible for purchase, cocoa buyers tend to analyze the cocoa to assess whether it is properly dried and meets the requirements set by the company. Cocoa buyers were reluctant to share the technology they used to evaluate cocoa, but they did share their techniques. 100 percent of those surveyed mentioned that they carry out laboratory tests to assess cocoa quality, 60 percent assess cocoa by sensory evaluation, and 20 percent carry out visual inspection, which is very rare in the sector. Laboratory tests are very common in the cocoa industry, as they enable cocoa to be assessed quickly, which can be an advantage for farmers and cooperatives in terms of payment. This shows the importance of both objective and subjective measurements.

80 percent of cocoa buyers interviewed indicated they encounter several business difficulties. The first challenge they face is with farmers, as most of the time, the cocoa is not properly dried and does not meet requirements, resulting in rejection by the buyer. This is a challenge because getting the cocoa to the buyer's warehouse costs time and money. If it is rejected, the cocoa has to be sent back to suppliers, resulting in further costs and delays. The problem of poorly dried cocoa highlights the need for better communication and greater transparency between buyers and farmers to ensure that quality standards are understood and respected. The second challenge is related to climate change. Climate change affects both farmers and buyers because it can cause much damage. If the farmers cannot deliver the quantity of cocoa necessary for production, this can lead to certain challenges that the buyers can face during their activities as well. Their activities can include production or exportation.

Lack of roads and loss of cocoa were other challenges mentioned by buyers during the interviews. Inadequate infrastructure can hamper the connection between farmers and buyers, as transporting cocoa becomes difficult, deterring buyers from sourcing cocoa directly from the villages. The shortage of buyers in some areas is due to insufficient road access – if buyers can't reach certain areas, farmers find it difficult to sell their entire cocoa production. In addition, cocoa losses often call into question buyers' operations, reflecting the sector's lack of traceability and transparency. Many buyers have complained about this problem for years, but solutions remain elusive. The proposed mobile application could solve this problem by providing cocoa data to help companies reduce high loss rates. Solving road access and traceability issues would benefit both buyers and farmers by improving supply chain efficiency. Buyers also mentioned that information is sometimes biased, as some farmers do not have accurate data, leading to operational problems. In addition, the lack of digital payment options creates further difficulties. Implementing digital payments could streamline operations and reduce errors caused by the lack of information between buyers, farmers, and cooperatives. A reliable and unbiased flow of information, made possible by a mobile application, could help align farmers and buyers through increased transparency and traceability since 100 percent of the buyers interviewed agreed that transparency and traceability are important in their operations.

Despite the operational hurdles, 100 percent of buyers said that "access to new markets" and "improved transparency and traceability" would encourage them to adopt the mobile application. The technology could help buyers identify the regions where the desired quantities of cocoa are located. It would also improve the transparency and traceability of transactions, which are critical points for buyers. Although challenges

persist, buyers recognize the value of digital solutions. Their universal willingness to adopt an application that expands market reach and provides essential supply chain data underscores the importance of this technology in improving buyers' operations and connecting them with new farmer suppliers.

2.1- Cocoa journey (Cooperative – Buyer's Warehouse)

Some cocoa buyers explained the process of collecting cocoa from farmers or cooperatives, giving an insight into the journey. The process generally begins in the cooperatives, where farmers' beans are grouped together. The beans are then subjected to rigorous quality control and grading to assess factors such as bean size, fermentation, and overall condition. Grading allows to classify the beans according to their quality. After grading, the beans are stored in warehouses before being sold directly to local chocolate manufacturers or processors or exported to international buyers. The cocoa will ultimately be used to create chocolate and other products. Brokers may enter the scene when the beans are in storage, visiting farmers or cooperatives to buy beans for resale locally or internationally. Tracking cocoa from farmer to end-buyer involves many stages where transparency can be undermined. The mobile application would improve traceability throughout this process, from collection by cooperatives to quality grading, storage, and transactions with brokers.

The findings of this study add to the body of knowledge on innovation diffusion theory and technology acceptance models like TAM2. Perceived usefulness is an important factor in determining adoption intention, according to TAM2 (Davis, 1989). The farmers' optimistic assessments of potential productivity/profit increases and access to beneficial information show a sense of usefulness that is consistent with TAM2. Buyers also see a real advantage in adopting the mobile application, as it will help improve transparency and traceability, and also help them access new markets and reach regions that have never been visited before. With the high adoption rate we got during the interviews, we are certain that farmers and buyers will be willing to adopt the mobile application right after it's released.

In addition, the results of this study lend credibility to several important ideas in Rogers' theory of innovation diffusion (Lundblad, 2003), particularly those dealing with innovation, communication channels, time, and social systems. According to the farmers, the mobile application is an innovation that could offer certain advantages over the status quo. The use of effective communication channels, such as farmers' cooperatives and agricultural extension agencies, will be necessary to publicize the app and offer training. Given that the application's complexity suggests a slow diffusion rate, a piloting phase will be crucial. Finally, for the innovation to be fully disseminated, it needs to be adopted by all farmers, cooperatives, buyers, and exporters in the social system.

Summary

Chapter 4 presented the results of the mixed-methods technique used for this study. Based on the qualitative and quantitative research we carried out, we were able to interview twelve farmers, five buyers, and three experts who were able to give us insights into the situation of the cocoa value chain in Ivory Coast, how some farmers perceive the adoption of the digital tool in their daily activities and also how buyers can incorporate the mobile application into their activities.

These interviews enabled us to understand the current state of the cocoa value chain in Ivory Coast from several angles. The data gathered during these interactions sheds light on various aspects, including how some farmers perceive the integration of digital tools into their daily farming practices. We gained valuable insights into how buyers within the cocoa value chain can effectively incorporate the mobile application we studied into their own operations.

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IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

Assessing digital tools to enhance transparency and traceability in the Cocoa Value Chain in Ivory Coast is the topic of this research. The problem that spurred interest in this topic is the challenges cocoa farmers face in Ivory Coast related to poverty even after selling their cocoa production, lack of market access, and limited knowledge and skills. With the advent of technology in our era, the study aimed to identify and evaluate digital solutions that could help address these issues by improving transparency and traceability.

The research utilized a mixed methods approach, including surveys, interviews, and document analysis, to gather perspectives from farmers, buyers, and experts. During the research phase, we interviewed 12 farmers,5 buyers, and 3 experts who contributed their insights to this research. Some limitations of the study included reluctance from some farmers to participate, as they hesitated to share sensitive information. Similarly, buyers did not disclose specific data deemed confidential. Experts also faced knowledge gaps that restricted their responses to particular questions. Ethical considerations were applied, as research participants were informed of the study's purpose to obtain consent. Participant confidentiality was maintained by securing their information and restricting access.

The research caused no mental or physical harm. While limitations existed, the mixed methods approach yielded valuable perspectives from diverse stakeholders to inform strategies for enhancing sustainability and transparency.

In this chapter, we will examine our research questions and explore the data we have collected. We will focus on the data, and at the end of our analysis, we will make recommendations that could add value to our research.

Implications

The study evaluated the effectiveness of digital tools in enhancing transparency and traceability in the cocoa farming industry. It found that a mobile application that caters specifically to the needs of cocoa farmers has high potential. About 72.7percent of farmers expressed their willingness to adopt the mobile application and features like market prices, farming advice, and buyer connections were perceived as very useful. The impact of the mobile application can be measured by assessing changes in transparency, productivity, and income through surveys and interviews conducted after implementation.

However, limited digital literacy, poor internet connectivity, and reluctance to change existing practices were identified as the main barriers to adoption. The study suggests that there are significant opportunities to overcome these barriers through training programs, network expansion, and incentives. Strategies should focus on cooperative-led training, simple and intuitive mobile application interfaces, and demonstrating benefits.

The study aligns with the purpose of evaluating mobile solutions to address cocoa farmer challenges through transparency improvements. It also supports the TAM2 and Diffusion of Innovation theories, demonstrating that usefulness and ease of use determine technology acceptance. However, the findings may not be fully generalizable due to small sample sizes. Nonetheless, the study provides valuable insights into farmer and buyer viewpoints.

In conclusion, the study highlights the potential of a tailored mobile application to benefit cocoa value chain actors in Ivory Coast. It addresses gaps in context-specific adoption factors and provides a starting point to

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design optimal implementation strategies. Further research can build on these mixed methods findings to realize supply chain upgrades and improve farmer livelihoods.

Recommendations

Mobile Application

To tackle the challenges that cocoa farmers in Ivory Coast face and enhance transparency and traceability in the cocoa value chain, it is strongly recommended to implement a mobile application exclusively designed for small cocoa farmers. Through interviews with farmers, buyers, and experts, we found that a well-designed app can be a game-changer by empowering farmers.

Training programs

To begin with, it is important to establish training programs that teach farmers how to use the mobile application. Since many farmers have limited formal education, training should be practical, hands-on, and not just theoretical. Cooperatives and government agricultural agency extension agents should work together to provide village face-to-face application training. The first pilot program can be implemented in the region where we have conducted the research: Lôh Djiboua. Instructors can offer verbal guidelines in local languages and allow farmers to practice entering information or connecting with buyers. Regular refresher training will also be necessary as the application is updated.

User Interface

Regarding mobile application design, the user interface must be intuitive and easy to navigate, even for the least technologically savvy users. Graphic icons, voice assistance in local dialects, and minimal typing can make the application more user-friendly. In addition, As most villages do not have a strong internet connection, another version of the app can be developed to help farmers in remote areas access crucial information and resources with limited bandwidth and connectivity issues.

The mobile application can also guarantee that transactions and interactions are conducted securely and transparently, minimizing the risk of fraud and ensuring the integrity of the verified data by enabling

farmers and buyers to create profiles by uploading identification documents. The mobile application may include an *Artificial Intelligence Application Programming Interface* to translate languages automatically to enable smooth communication between farmers and purchasers. In addition to promoting successful communication, this feature will help buyers locate certain areas that provide good cocoa they need by using an AI-powered filtering tool.

Product Launch

Before launching the mobile application in Ivory Coast, it would be prudent to test it in a few communities to identify technical bugs or features that need to be improved. User feedback can be gathered through focus groups and surveys and any necessary adjustments made before extending the roll-out. The "test and learn" approach makes sense for optimizing product-market fit.

Digital Payment

A digital payment system that offers a quick and secure way to execute transactions may be included in the mobile application to address the payment issue with farmers, easing the payment process for both sides. Integrating a USSD payment gateway into the mobile application will enable farmers to receive future payments, even without the Internet.

Premium features

Also, premium features like forecasting and analytics could be implemented. Large buyers could be ready to spend more on sales forecasts, data visualizations, mapping tools, and other insights based on buying habits.

QR Codes for cooperatives

Cooperatives can create a QR code for each bag of beans they collect to track the cocoa beans. These codes can be scanned to reveal the corresponding digital profiles, allowing users to follow the progress of the beans. Each change in the parties' possession over the bags as they are delivered to the warehouses is noted in the application, preserving a clear chain of custody. Managers at the warehouses may verify the movement history of the incoming bean bags by rescanning the QR codes on them. Finally, the cooperatives digitally transfer ownership into the program when the aggregated beans are sold to customers using created invoices. The buyer closes the loop by keeping track of information like weight, quality rating, and payments.

Partnerships

On the technical side, partnerships must be established with cell phone operators and government agencies to extend network coverage in rural cocoa-growing areas. Internet connectivity is essential if farmers are to reap the full benefits of the application.

Conclusions

The objective of this study was to assess digital tools, especially a mobile application, to enhance transparency and traceability within Ivory Coast's cocoa supply chain. Farmers, buyers, and experts provided insightful feedback for the research that identified a number of constraints, including restricted access to markets and information, among other relevant problems. These results highlight the main issues that must be resolved in order to provide a complete solution.

However, cocoa farmers are highly willing to adopt mobile apps that offer solutions such as accessing market prices or extension services. Buyers also acknowledge the potential of digital tools in expanding

market reach and cocoa chain transparency.

In summary, a well-designed mobile application has the potential to improve transparency and address information gaps between cocoa value chain actors. Key factors in ensuring widespread acceptance and impact include targeted training programs, good user interface design, network expansion, incentives for adoption, and pressure for transparency. Despite challenges like low education levels, this study provides ample evidence that a mobile-based approach can significantly benefit farmers, buyers, and consumers seeking ethically and sustainably sourced cocoa. Further research can build on these findings to develop optimal strategies for mobile application implementation and measure tangible supply chain improvements in the Ivorian cocoa sector.

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APPENDIXES

Appendix A: Capstone Folder

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Appendix B: Research Questionnaire for farmers

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Appendix C: Consent forms for farmers

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Appendix D: Research Questionnaire for Buyers

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Appendix E: Consent forms for Buyers

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Appendix F: Interview Guides for Experts

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Appendix G: Interviews with Experts

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Appendix H: Consent forms for Experts

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Appendix I: Ethics Clearance

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