Leveraging Circular Business Models to Achieve Living Incomes for Ivorian Cocoa Farmers

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Abstract

Purpose: value chain transparency and circularity are tested as concepts that could enable Ivorian cocoa farmers to maintain a living income, defined as the amount needed for a household to afford a decent standard of living. The Fair Score Framework is a proposed conceptual framework designed to measure value chain fairness. Its development responds to calls in the literature for improved implementation of the circular economy.

Methodology: this study uses a qualitative approach, combining a narrative review with a conceptual framework development design. The primary dataset includes a farmer questionnaire (n=215), consumer questionnaire (n=212), and semi-structured interviews (n=12). The research is guided by consumption theory, drawing on Keynes, Friedman, and Modigliani.

Findings: farmers suggest that adopting circular practices yields minimal income gains unless value chain inequalities are structurally addressed. Consumers from six countries increased the share paid to farmers by 7.41% after watching an informational video. A Cronbach's Alpha of 0.79 confirms acceptable reliability. Interviewees noted that while circularity may reduce waste, it cannot ensure poverty alleviation in its current form. This presents an opportunity to develop entrepreneurial circular business models that address income distribution.

Originality: entrepreneurial circular business models could be leveraged by incorporating the Fair Score Framework, using the United Nations Sustainable Development Goals, Nutri-Score label and Organization for Economic Co-operation and Development Circularity Scoreboard as reference points.

Highlights

- Fair Score Framework: conceptual tool designed to measure value chain fairness
- Entrepreneurial Circular Business Models are to integrate the Fair Score Framework
- The Fair Score Framework will help society achieve the 2030 UN SDGs on time
- Consumers in six countries increase farmers' share by 7.41%; $\alpha = 0.79$

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1. Introduction

1.1. Problem statement

A living income is defined as the amount needed for a household to afford a decent standard of living (Anker & Anker, 2017). Although the term 'living income' is used differently across the cocoa value chain, research on cocoa farmers' income is conducted in several countries worldwide, including Cameroon (Folefack et al., 2021), Indonesia (Octavia et al., 2022), and Papua New Guinea (Scudder et al., 2022). Côte d'Ivoire is a world leading cocoa producer, and yet, it appears that most Ivorian cocoa farmers fail to earn a living income (Kongor et al., 2024; van Vliet et al., 2021). Trapped in cycles of economic poverty (Gboko et al., 2021), farmers' full human potential is wasted (Maslow, 1943). The increased inequality between rich and poor causes political instability (McKnight, 2019) and armed conflict (Ismail & Olonisakin, 2021).

This research tests value chain transparency (VCT) and the circular economy as concepts that could be used to achieve a more sustainable cocoa economy; one through which farmers can maintain a living income.

1.2. Rationale

The living income concept is inextricably linked to entrenched inequality in the cocoa value chain (CVC). Inequality is characterized by the unequal distribution of income, power, and resources among stakeholders – from producers to retailers (Neilson et al., 2020). Crucially, inequality is a form of market failure, which can impede fairness in society (Ferreira et al., 2022). Market failure occurs when the allocation of goods and services by a free market is not Pareto-efficient, leading to sub-optimal outcomes for society (Krugman et al., 2023). Pareto-efficiency is understood as the economic situation where resources are distributed in such a way that improving one person's wellbeing would inevitably reduce someone else's (Endörfer & Larue, 2024). In cocoa, market failure manifests when some stakeholders earn a living income while others - in this case farmers - fail to do so.

Adapting the CVC such that farmers can earn a living income is justified for three main reasons. Firstly, farmers deserve a living income for their labour (Canning, 2023; Gröne et al., 2023). Secondly, improving farmers' economic stability reduces the likelihood of social unrest (Bedasa & Deksisa, 2024; Nguyen et al., 2023). Finally, consumers ought to have access to products sourced from fair value chains (Bennett & Grabs, 2025; Grabs et al., 2024).

1.3. Definitions

The circular economy is an economic and political framework aimed at reducing waste in all its forms (Kirchherr et al., 2017, 2023; Morseletto, 2020; Shevchenko et al., 2023). VCT is a framework used by firms to gain visibility into their supply chain and disclose relevant information to consumers for competitive advantage (Ko et al., 2023; Kraft et al., 2022; Nyamah et al., 2022; Porter, 2008). VCT is akin to social licence to operate (Dumbrell et al., 2020) in that both concepts emphasize effective communication and public trust as critical factors of a firm's reputation.

A Circular Business Model (CBM) enables a firm to fulfil its mission whilst minimizing environmental and social costs (Kravchenko et al., 2019; Sinkovics et al., 2021). CBMs contribute to the circular economy by designing out waste and pollution, keeping products and materials in use, and regenerating natural systems (Mhatre et al., 2021). These principles guide firms in creating long-term value by promoting resource efficiency and waste reduction (Lahti et al., 2018).

Entrepreneurship is often defined as a "*skill*" (Abel et al., 2024, loc. 269), where an individual with an idea takes the risk of disrupting the market with a new service or product (O'Reilly & Binns, 2019). From a management perspective, entrepreneurship can be described as a mindset that is opportunity-obsessed (Ratten, 2023), holistic in approach (Theodoraki et al., 2022), and rooted in balanced leadership (Pauceanu et al., 2021). Modern economic theory recognises entrepreneurship as a distinct factor of production, alongside labour, land, capital, and the state of technology (Blanchard et al., 2021; Erken et al., 2018; Krugman et al., 2023).

An Entrepreneurial Circular Business Model (ECBM) integrates the core principles of entrepreneurship with those of CBMs. ECBMs are characterized by their adaptability. Firms that implement ECBMs often rethink product life cycles, designing for reuse, and creating business strategies that emphasize long-term value creation over short-term profits (Toth-Peter et al., 2023). ECBMs satisfy a growing need in society for waste reduction. ECBMs allow firms to be competitive (Porter, 2008) because they are environmentally responsible (Suchek et al., 2022).

This article shows how ECBMs, as a subset of the circular economy (Awan & Sroufe, 2022), can be leveraged by cocoa farmers to achieve and maintain a living income (Brenner, 2018).

1.4. Gaps in current empirical studies

Existing literature discusses the circular economy, circular business models, entrepreneurship, and entrepreneurial circular business models. The literature also shows that the living income problem persists throughout the cocoa value chain. Yet most work focuses on the environmental and economic dimensions of circular economy implementation, leaving the social dimension – particularly farmers' living income – underdeveloped. As a result, there is a missing link between circular economy scholarship and the living income challenge in the cocoa value chain. To date, no actionable framework integrates circular economy principles in a way that effectively addresses cocoa farmers' living income. This research fills that gap by proposing a multidimensional framework that incorporates environmental, economic, social, and governance dimensions, while explicitly foregrounding the missing social dimension of circular economy implementation.

1.5. Aim of the article

This article aims to present a new conceptual framework that builds on the circular economy concept with the purpose of enabling cocoa farmers in Côte d'Ivoire to achieve living income targets. The proposed conceptual framework is the result of extensive research based on two broad aims outlined in section 3.1.

2. Literature review

2.1. Smith and Piketty – overview of the economy

Applied to the context of CVC circularity, Smith's perspective suggests that farmers, working in their own self-interest, are led by an "*invisible hand*" (2008, loc. 4,932) that works to promote farmers' economic advancement as well as that of society. By pursuing their own interest, the farmer often supports the free market economy better than if they put society's interests ahead of their own. Farmers need no persuasion to avoid doing trade for the sake of the public good.

According to Piketty (2017), while a free market economy has the potential of benefitting society through the transmission of knowledge and skills, it also has the capacity to threaten democracy and social justice. The most dangerous risk is caused by "*the fact that the private rate of return on capital, r, can be significantly higher for long periods of time than the rate of growth of income and output, g*" (Piketty, 2017, loc. 14,045). Applying Piketty's argument to the Ivorian CVC, stakeholders who benefit from 'r' – mostly non-farmers – will always grow their wealth faster and longer than those who only have 'g' – farmers, for the most part.

Smith and Piketty were chosen because they provide broad economic frameworks relevant to CVC circularity. Smith situates the discussion within classical market mechanisms whereas Piketty highlights macroeconomic inequality dynamics. Their combined perspectives are deemed suitable for an overview of the economy before delving into theories focused on consumption behaviour.

2.2.   Keynes, Friedman, and Modigliani – consumption theory

Consumption theory attempts to explain consumer decision-making. Within consumption theory, economists have developed distinct hypotheses to understand consumption patterns. These hypotheses offer structured models that help predict how income, expectations, and life-cycle stages influence spending and saving. The following section applies three key hypotheses to the Ivorian CVC: Keynes' Absolute Income Hypothesis (AIH), Friedman's Permanent Income Hypothesis (PIH), and Modigliani's Life-Cycle Hypothesis (LCH).

The choice of the AIH, PIH and LCH is justified because they are relevant to the cocoa value chain. Each of the theories provides analytical frameworks to explain how consumers make decisions that ultimately determine demand for cocoa and cocoa-based products. The AIH establishes a historical baseline in Keynesian macroeconomics, while the PIH and LCH are refinements that address the limitations of the AIH by integrating expectations and intertemporal decision-making.

2.2.1. Keynes' Absolute Income Hypothesis
In the AIH, Keynes calculates that as income rises, the share spent falls and the share saved rises (2018). Applied to the demand side, consumers may favour ethical cocoa and accept a premium, but the rise in demand will be less than proportional to income growth. In macro terms, a rise in employment and aggregate income therefore does not convert one-for-one into extra consumption (O'callaghan et al., 2022). Instead, there is a curved effect (Baselgia & Foellmi, 2022) due to a decline in the average propensity to consume at higher incomes. Applied to the supply side, smallholder farmers must weigh the opportunity cost of daily survival against long-horizon circular investments.

2.2.2. Friedman's Permanent Income Hypothesis
Friedman developed several theories on consumption to fill the supposedly unexplained knowledge gaps left by Keynes's AIH (Drakopoulos, 2021). According to Friedman's PIH, a consumer's spending is determined by their permanent, as opposed to their current, income – where permanent income is defined as what a consumer reasonably expects to earn on a consistent, ongoing basis (2020). Applying the PIH to the CVC, farmers may wish to invest in circular practices but face difficulties due to high upfront costs and limited access to savings or credit. Similarly, consumers may demand ethically produced cocoa but are limited by their immediate financial resources, even if they expect higher future income.

2.2.3. Modigliani's Life-Cycle Hypothesis
Applying Modigliani's LCH (2005) to the CVC, stakeholders at every level tend to smooth out their consumption during their lifetime by borrowing when their income is in a trough (e.g. during periods of low cocoa prices), and saving when their income is at a peak (e.g. during harvest peaks or when prices rise). This planned consumption results in a curved shape of savings that is low during youth and old age and high in middle age. The LCH also claims that savings are not carefully passed on to the next generation at the end of the steward's life.

2.3.   Leveraging ECBMs

Under the broader circular economy framework, ECBMs aim to reduce waste and recover value (Kirchherr et al., 2023). ECBMs allow firms to be competitive because they are environmentally responsible (Cullen et al., 2021; Poponi et al., 2020; Suchek et al., 2022). In contrast, linear models follow a take-make-dispose approach, extracting resources to produce goods that eventually become waste (Tan et al., 2022).

Since poverty suppresses human potential (Maslow, 1943), ECBMs offer a pathway to reducing poverty and enabling farmers to reach their full potential (Erdiaw-Kwasie, 2023). Cocoa production plays a central role in Côte d'Ivoire's social and economic development (Coulibaly & Erbao, 2019), and agricultural exports significantly bolster the national balance of payments (Giller, 2020). Thus, ensuring that farmers earn a living income can yield broad developmental benefits.

Yet, persistent obstacles hinder implementing ECBMs. The circular economy has been criticized for its 'vague narrative' (Niskanen et al., 2020). The ISO 59000s series of publications addresses the gap of an actionable framework for the circular economy, but apparently it has not yet been fully tested in the cocoa value chain. Thus, for both firms and policymakers it seems there is no consistent definition and framework

to consolidate the circular economy in the cocoa value chain – a challenge that mirrors broader conceptual ambiguities in sustainability frameworks (Ingram, 2025). This lack of clarity hinders efforts to develop measurable goals. Moreover, the transformation from linear to circular cocoa models lacks practical roadmaps, leaving firms uncertain how to restructure operations (Corvellec et al., 2022). Empirical research confirms that deep circular shifts demand substantial upfront investment, supportive regulations, and consumer behavioural changes (Försterling et al., 2023). These financial and behavioural constraints obstruct firms' ability to sustain circular transformations.

Successfully addressing both conceptual ambiguity and implementation gaps is vital to realizing the potential of ECBMs – not only in cocoa but across multiple value chains.

2.4. Proposed conceptual framework - The Fair Score Framework

This article introduces the Fair Score Framework (FSF), a new conceptual framework that can be used to measure the fairness of a value chain. The FSF is designed to inform the consumer with the help of a user-friendly overall score. The FSF score could be a front-of-pack, value chain fairness label. Table 1 provides a summary of the indicators derived from the literature that will further be validated in the study.

Table 1. The Fair Score Framework

Criterion	Indicators based on current research
Farmer's pay	Cocoa farmers achieve and maintain a living income (Anker & Anker, 2017).
Transparency	Value chain transparency is used as a framework to gain competitive advantage (Porter, 2008).
Circularity	The value chain is circular; it aims to reduce the waste of resources in all its forms (Kirchherr et al., 2023).
Forced child labour	There is no forced child labour (Thévenon & Edmonds, 2019).
Excessive deforestation	There is no excessive deforestation (Renier et al., 2023).
Entrepreneurial Circular Business Models	ECBMs are operating profitably (Blanchard et al., 2021; Lahti et al., 2018; Suchek et al., 2022).
Individual's full potential	The full potential of individuals is not wasted (Maslow, 1943).
Sustainable Development Goals	The value chain achieves the UN SDGs (United Nations, 2025).
Demand	The level of consumer demand for the product and/or service justifies the operation of business (Friedman, 2020; Keynes, 2018; Modigliani, 2005).
Common good	The value chain serves the common good (OECD, 2020a, 2022, 2023; Sachs et al., 2019).
Total score out of 100	
Fair Score letter (A to E) and colour	

Despite extensive research on living income issues in the cocoa value chain, there is a missing link between circular economy thinking, consumption theory, and actionable strategies to address cocoa farmers' living income challenges. While traditional models such as the AIH, PIH, and LCH explain different facets of consumption behaviour over time, they do not appear to have been integrated with a framework that links ethical consumption, value chain dynamics, and social justice outcomes in cocoa markets. The FSF aims to bridge this gap by combining these theoretical insights with qualitative evidence. The next section outlines the qualitative research design and methodology used to develop and validate the FSF, whilst answering the research question.

3. Methodology

This study uses a qualitative approach, combining a narrative review with a conceptual framework development design. The narrative review synthesised interdisciplinary literature on the circular economy, circular business models, transformation toward sustainability, and living income in agricultural value chains. This synthesis enabled the identification of gaps across environmental, economic, social, and

governance dimensions. Building on these insights, the research design was structured to meet the study's aim by developing a multidimensional framework that links circular economy implementation with the living income challenge in the cocoa value chain. As outlined in section 3.2, the primary focus of this article is answering research question 4, while RQ1-3 provide the contextual foundations necessary for the framework's development.

3.1. Aims, theoretical framework, and research approach

The research has two broad aims. The first is to elicit consumer opinion on the relationship between improved value chain transparency and the living income of cocoa farmers in Côte d'Ivoire. The second is to explore the potential impact circularity could have in enabling farmers to maintain a living income.

Consumption theory (Friedman, 2020; Keynes, 2018; Modigliani, 2005) served as theoretical framework to guide the interpretation of the data. The units of analysis were farmers (n=215), consumers (n=212) and interviewees (n=12).

There are several reasons why a qualitative approach (Bell et al., 2019) was deemed most suitable to achieve the research aims, three of which will be highlighted. Firstly, qualitative research is particularly effective at interpreting subjective experiences (Shipp & Jansen, 2021). Secondly, a qualitative approach tends to support the deep exploration of ideas, experiences, beliefs, and cultures (Knott et al., 2022). Finally, the central research question and four sub-questions (see section 3.2) were designed to describe phenomena and were expressed as 'what' and 'how' questions (Onwuegbuzie & Leech, 2006). This format is consistent with qualitative research questions in the literature, including but not limited to wind energy (Karakislak et al., 2023), children's rights (Sun et al., 2023), refugees (Saleh et al., 2023), and end-of-life care (Flemming et al., 2019).

3.2. Central problem and research questions

The research's central problem is that Ivorian cocoa farmers fail to maintain a living income (Giller, 2020; Waarts & Kiewisch, 2021). Although interventions such as Fairtrade certification and the Living Income Differential have partially resolved the problem, the literature shows that further improvements are needed (Boysen et al., 2021, 2023; Staritz et al., 2022).

To contribute to the literature, the following central research question was asked: "to what extent do consumers believe that VCT and circularity would enable Ivorian cocoa farmers to maintain a living income?" The research questions arising from the literature review are:

1. What are the existing constraints of the Ivorian cocoa value chain?
2. How do consumers perceive value chain transparency?
3. To what extent do consumers believe that achieving circularity would enable cocoa farmers to maintain a living income in Côte d'Ivoire?
4. How could entrepreneurial circular business models be leveraged so that cocoa farmers in Côte d'Ivoire achieve circularity and maintain a living income?

The focus of this article is answering research question 4. The output should help bridge identified knowledge gaps and contribute to developing a new conceptual model applicable in industry (see section 5 – Discussion).

3.3. Literature review method

The literature review was conducted using the narrative review method (Snyder, 2019). Adapted keywords were chosen at three distinct phases, inspired by creative problem-solving methodologies used in design thinking (Liedtka, 2018). For example, the diverge phase included keywords 'circular agri-food', 'cocoa by-products' and 'consumption theory', among others. The converge phase included keywords 'provenance', 'sustainability', and 'customer engagement', among others. Finally, the emerge phase included keywords 'constraints', 'value chain transparency', 'circularity', and 'business models', in line with the four research questions. The diverge (n=208), converge (n=183), and emerge (n=102) phases contributed a total of n=493 included articles.

3.4. Grouping

Following Hennink & Kaiser (2022), 'grouping' refers to the analytic process of clustering related data or concepts to support interpretation and saturation assessment. In this study, grouping involved organising questionnaire and interview questions according to shared characteristics such as topic focus, conceptual relevance, analytical purpose, and alignment with constructs identified in the literature review. This enabled the researcher to link each research question to the most relevant evidence drawn from the literature review, the farmer questionnaire, the consumer questionnaire, and the semi-structured interviews. To illustrate, research question 4 (RQ4), the focus of this article, was answered using the literature review, farmer questionnaire question number 26, consumer questionnaire questions 20, 22-25, 29-31, 35, 40, 51-56, and 59-60, and the interviews. An example interview question was: "how could entrepreneurial circular business models be leveraged so that Ivorian cocoa farming families maintain "a decent income" (Waarts & Kiewisch, 2021, p.56)?" This open-ended question invites the respondent to brainstorm how ECBMs could be implemented.

3.5. Farmer questionnaire: the San-Pédro region in Côte d'Ivoire (n=215)

A 'consent to participate in the research' introduction was used during the invitation to take part. This process was respected for all respondents: farmers, consumers, and interviewees. Respondents were not "recruited"; they were invited to participate and had the option of skipping questions or ending the questionnaire at any point.

The farmer questionnaire allowed for detailed insights into ground-level factors influencing farming decisions. Both the pilot and revised questionnaires were conducted in the San Pédro region of Côte d'Ivoire. The region is represented by the Kroumen people, along with several other ethnic groups and nationalities, including Baoulé, Dioula, Burkinabé, and Malians (Traoré & Dzifa Torvikey, 2022).

The questionnaire was distributed in French, the main spoken language. Responses were collected in French, and upon completion of the data collection, answers were translated into English. There was a total of 215 farmer respondents. Potential loss through interpretation was minimised firstly because the researcher speaks fluent French and secondly because the researcher used state of the art translation software to verify translations. There would have been greater potential loss through translation if the farmer questionnaire had been distributed in English. Most if not all farmers in the region speak French but not English.

Three main implications can be drawn from the fact that most farmer respondents were illiterate. In terms of data collection, there was a need for each farmer respondent to be accompanied during the completion of the questionnaire. In terms of implementing ECBMs and the Fair Score Framework, there is a significant potential improvement in farmer education, health, and incomes. Finally, it is possible that illiterate farmers' answers differed from what they would have given if they had completed the questionnaire on their own.

3.6. Consumer questionnaire: university staff (n=6) and students (n=206)

After careful consideration, the decision was made to elicit responses from consumer respondents located at a university. The universities, colleges, and institutions that satisfied the inclusion criteria were found in France, Germany, the Netherlands, Switzerland, the UK, and the USA. Distributing the questionnaire to university staff and students was both cost effective and aligned with literature advocating universities as centres for the development of circularity (Aarikka-Stenroos et al., 2021). A total of 6 staff and 206 students responded. The staff data was analysed separately from that of the students.

The consumer questionnaire revealed consumer motivations behind purchasing decisions as well as suggestions for improving the cocoa business model. A pilot version was tested, and the revised version was translated into French and German. Translation was completed with the support of colleagues, the local community, and a professional translation service.

3.7. Semi-structured interviews: respondents from varied backgrounds (n=12)

The purpose of the semi-structured interviews was to fill gaps identified after analysing the farmer and consumer questionnaire data. To optimise the likelihood of filling these gaps, interview respondents were invited from both in (n=3) and outside of (n=9) academia, as shown in Table 2.

Table 2. Interviewees' area of work and estimated years of experience (n=12)

Interviewee	Area of work	Estimated years of experience
1	Entrepreneur	30
2	Entrepreneur	30
3	Entrepreneur	10
4	Entrepreneur	20
5	Academia	40
6	Academia	30
7	Academia	30
8	NGO	25
9	NGO	30
10	Corporate	20
11	Corporate	25
12	Former cocoa cooperative manager	10

There was a total of 12 interviewees, who answered in English, French, or German. Some of the interviewees are, or have been, very much involved in the cocoa value chain, some to a moderate extent, and others not at all. By inviting interviewees from populations outside of the university context (van de Werfhorst, 2020), the applicability of the findings to the broader population might well have been improved to a certain extent.

The questionnaires were distributed to farmers and consumers by the researcher, colleagues, lecturers and volunteers. The interviews were conducted sequentially by the researcher. The interviewees were invited by the researcher.

3.8. Data saturation and convenience sampling

New respondents were invited until data saturation was achieved. In this study, saturation was considered reached when additional responses no longer introduced new ideas or insights relevant to the research question (Hennink & Kaiser, 2022). For example, questionnaire respondents consistently linked value chain transparency to trust, traceability, workers' pay, and working conditions. These same ideas re-emerged in the interviews, even though participants did not know one another and were asked slightly different questions.

The convenience sampling method (Etikan et al., 2016) was used to collect data through the farmer and consumer questionnaires. This implied a sample less representative of the population, a risk of sampling bias, and of selection bias, reducing external validity. However, it also presented the opportunity to increase internal validity. Four threats to internal validity were reduced: history (conditions were kept stable as far as reasonably possible for each sample), maturation (the time lapse between identifying the problem and collecting data was kept reasonable), attrition (the research was limited to a reasonable timeframe), and instrumentation (the scales were kept constant).

3.9. Research ethics

Informed consent was obtained from all respondents. Before taking part in the research, respondents were fully informed about the purpose of the study and agreed to the collection and analysis of their responses. Participation was entirely voluntary, and respondents were free to withdraw at any time without penalty. All

data was anonymised to protect sensitive information, and responses were treated as confidential. No identifying information has been shared or published. Participants were also informed that the research findings may be used in academic publications, presentations, or other research-related outputs.

Ethical approval for this study was granted by the Ethics Review Committee of the host institution, the Royal Agricultural University, prior to data collection. Key ethical considerations in this research include:

1. Respecting the dignity of all participating farmers, consumers, and interviewees.
2. Ensuring the business confidentiality of firms and stakeholders throughout the cocoa value chain.

4. Results

This section begins with an overview of the datasets and an account of existing constraints along the Ivorian cocoa value chain according to farmers. Against this backdrop, the article focuses on the research question, "how could ECBMs be leveraged so that cocoa farmers in Côte d'Ivoire achieve circularity and maintain a living income?" To provide a comprehensive answer, several sub-questions are explored. First, what are farmers' views on the effect of circularity on their living income? Second, would consumers increase the share paid to cocoa farmers? Third, how do consumers define entrepreneurship? Fourth, could circularity be designed to reduce economic poverty? Finally, how could ECBMs be leveraged?

4.1.   Overview of the datasets

Understanding a few essential characteristics of the respondent groups helps contextualise the findings that follow. This study included cocoa farmers, university staff members, university students, and interviewees from organisations connected to the cocoa value chain. These groups differed in income levels, educational backgrounds, and age profiles. Table 3 summarizes the median income, most common education level, and median age for each group.

Table 3. Income, education level, and age of respondents

	Farmers (n=215)	Staff (n=6)	Students (n=206)	Interviewees (n=12)
Median income per month in £	£108 (n=211)	£3,164 (n=6)	£400 (n=193)	NA
Most common education level	54.2% no formal education (n=214)	50% undergraduate (n=6)	52.6% undergraduate (n=209)	NA
Median age in years	41 years old (n=215)	25 years old (n=6)	22 years old (n=209)	NA

The median monthly income was £108 for farmers (Mean = £121; SD = £61), £3,164 for staff (Mean = £3,593; SD = £2,066), and £400 for students (Mean = £552; SD = £569). Currency conversions were calculated using the last day of the month when the questionnaire was distributed, which was November 2024 for the farmer dataset[2]. Significantly, more than half of farmers were illiterate. In comparison, at least half of the consumer respondents had completed an undergraduate degree, highlighting an education gap. The median age was 41 years for farmers (Mean = 43 years; SD = 10 years), 25 years for staff (Mean = 30 years; SD = 13 years), and 22 years for students (Mean = 23 years; SD = 4 years). The interviewees were entrepreneurs, academia, NGOs, corporations, and a former cocoa cooperative manager.

4.2.   Existing constraints according to farmers

An account of current problems faced when growing and selling cocoa in Côte d'Ivoire was elicited from 215 farmers (see Figure 1).

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[2] £1 = 789 CFA Francs on 30 November 2024 (www.xe.com, 2025)
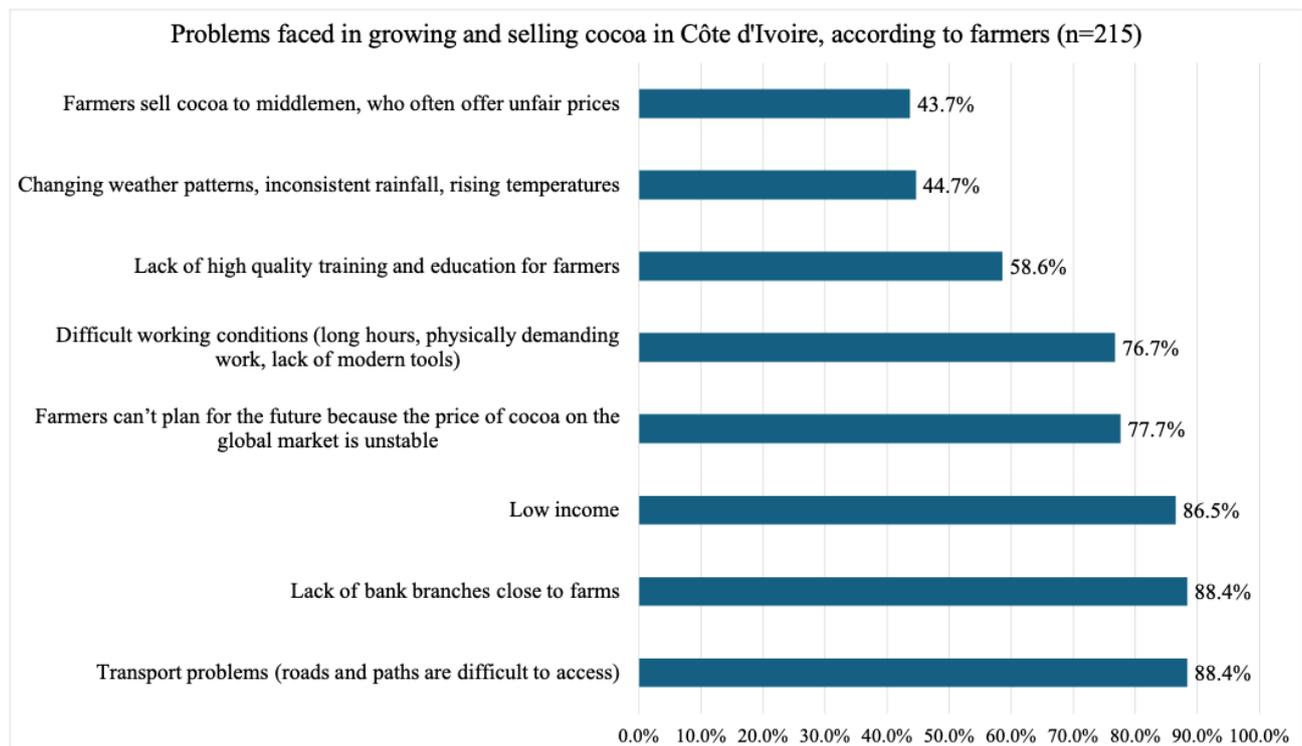
Figure 1. Problems faced in growing and selling cocoa in Côte d'Ivoire, according to farmers (n=215)

More than 80% of the sample identified three constraints: transport problems, a lack of bank branches close to farms, and low income. More than 70% identified unstable world cocoa prices making it difficult for farmers to plan for the future, and difficult working conditions. Finally, more than 40% identified a lack of high-quality training, changing weather patterns, and unfair prices from middlemen.

The sampled farmers were then asked the extent to which they believe their income enables them to meet their family's basic needs, where 1 means not at all and 10 means very much so. The average score was 4.80 (SD=1.62). This was surprising, as it does not reflect an expected score of 1-3, given that 86.5% of the sampled farmers indicated low income as an existing problem. From this, one could interpret that while low income is collectively seen as a present constraint, each family shows varying levels of resilience to meet their family's basic needs with the income they receive currently.

4.3.   Farmers' views on circularity and living income

Farmers were asked whether, in their view, achieving circularity could help them maintain a living income. The responses (see Figure 2) did not converge on a definitive "yes" (a score of 10) or "no" (a score of 1).
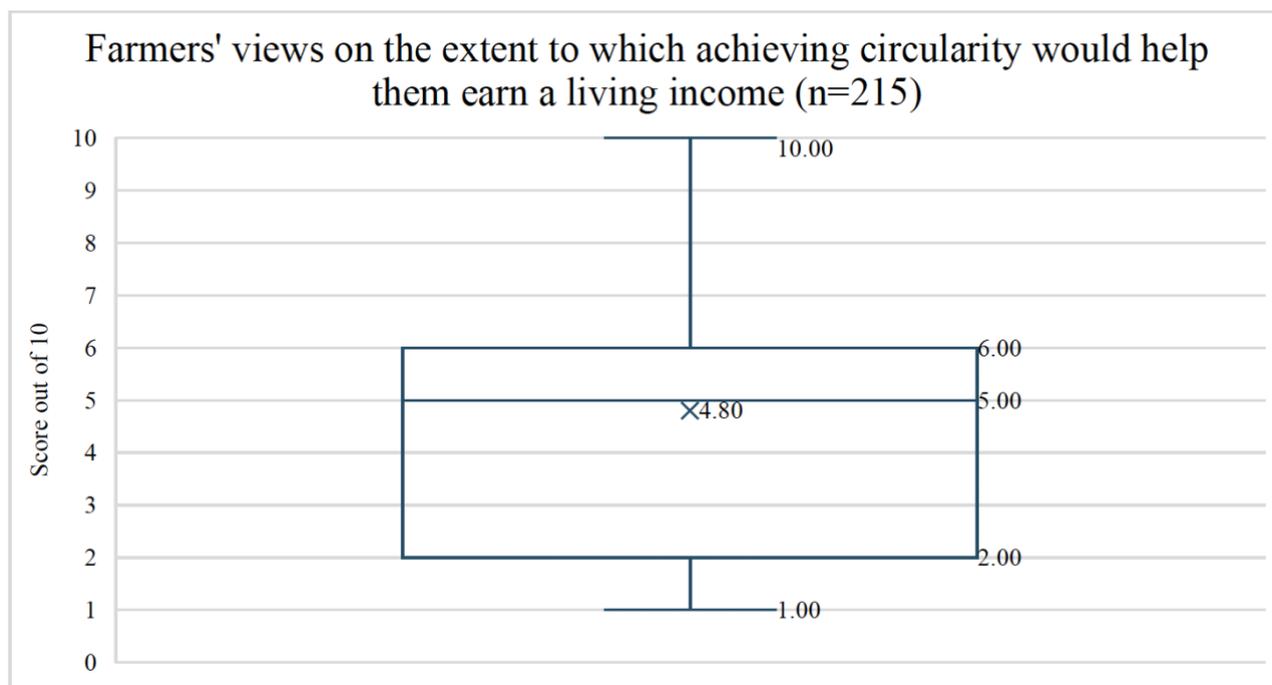
Figure 2. Farmers' views on the extent to which achieving circularity would enable them to maintain a living income (n=215)

According to Figure 2, farmers are divided on whether circularity would help them secure a living income. The mean (4.8), median (5), and standard deviation (2.31) point to dispersed responses centred around neutrality – indicating farmer uncertainty about whether circularity can ensure a living income. This uncertainty could be a symptom of the deep-rooted difficulty of resolving living income challenges in cocoa production, regardless of proposed solutions. An alternative explanation is farmers' unfamiliarity with the concept of circularity. However, the threat of this occurring was reduced by explaining the concept to each respondent and using synonyms in the questions themselves. For example, "would making changes to reduce waste in the cocoa business help you earn enough as a farmer to cover your family's basic needs?" Overall, the complexity of circularity's potential impact of cocoa farmers' living income led to the exploration of new, more effective solutions by integrating findings from the questionnaires and interviews. This culminated in the development of a new conceptual framework: the Fair Score Framework (FSF).

Overall, the broad range of answers expressed in Figure 2 suggests there are complex barriers (e.g. immediate income constraints, uncertainty, and market inequalities) that would need to be resolved for circular business models to be viable for cocoa farmers in Côte d'Ivoire. The AIH would suggest that the variation in responses indicates that farmers are influenced by their current disposable income. Those facing urgent financial constraints must prioritize immediate consumption over longer-term investments such as circularity. The PIH might suggest that farmers' investment decisions in circularity are influenced by their long-term income expectations. Those with pessimistic forecasts of cocoa market stability are less inclined to adopt circular practices. The LCH would affirm that farmers' ability to invest in circularity depends on their life-stage and on income fluctuations. Those with greater income stability (middle-aged farmers) may be more willing to invest in circular practices, whereas younger or older farmers may be more concerned with short-term financial stability. Piketty's critique of inequality claims that farmers may view circularity with scepticism if they believe systemic inequalities in the CVC prevent them from benefitting properly, no matter their efforts.

4.4. Consumers' willingness to increase farmers' share

Consumer willingness to increase the share paid to farmers was measured to evaluate circularity's potential of addressing the living income problem.

Table 4. shows that, after viewing an informational video about cocoa farming challenges, consumers in all sampled countries (UK, Germany, France, USA, and the pooled dataset including Switzerland and the Netherlands) increased the share for farmers.

Table 4. Arithmetic mean percentage share of consumer price attributed to farmers by consumer respondents before and after watching an informational video

	UK (n=45)	Germany (n=46)	France (n=47)	USA (n=47)	Pooled dataset with UK, Germany, France, USA, Switzerland, and the Netherlands (n=212)
Mean % share attributed to farmers before watching informational video3	30.5%	28.9%	32.1%	30.7%	31.6%
Mean % share attributed to farmers AFTER watching informational video	37.6%	36.8%	41.7%	37.4%	39.0%
Paired samples t-test: difference of the means	-7.07% at the p<0.001 level of significance	-7.84% at the p<0.001 level of significance	-9.52% at the p<0.001 level of significance	-6.67% at the p<0.001 level of significance	-7.41% at the p<0.001 level of significance
Cronbach's Alpha*	0.669	0.713	0.690	0.815	0.790

* Cronbach's Alpha, α, indicates the overall reliability of a scale (Field, 2018). In general, an α value between 0.7-0-8 indicates good reliability (Kline, 1999) in (Field, 2018, p.826).

The country datasets show increases to farmers' pay, in descending order as follows – France up by 9.52%, Germany up by 7.84%, UK up by 7.07%, and the USA up by 6.67%. Each of the datasets had an acceptable level of reliability between $\alpha = 0.6\text{-}0.9$. The most reliable datasets were Germany at $\alpha = 0.713$ and the pooled dataset at $\alpha = 0.790$, given that both these values fell within the stricter target range of $\alpha = 0.7\text{-}0.8$. The pooled dataset revealed an increase of 7.41%. Overall, the change in the means indicates that consumers are prepared to change their opinion on what they believe farmers should be paid. This change implies that a well-informed consumer base can play a pivotal role in ensuring farmers receive a greater, and fairer, share of the profits.

Interviewee 10 provided a farmer-level blueprint that echoed the consumer-led adjustment shown in table 4 by saying:

"...and do you know what the (farmers) decide to do when they earn the extra money? The first thing they do is send their child to school; they don't leave them hanging around."

Interviewee 10's perspective supports the notion that community improvements in education, income, and health are likely to result from farming communities' enhanced ability to pursue entrepreneurial ventures (Yeboah et al., 2022) through ECBMs.

The observed change in consumer behaviour – specifically the increased willingness to pay a higher percentage to farmers – shows that ECBMs could play a critical role in resolving the living income problem for cocoa farmers. Even among student consumers, who may have limited financial resources, raising awareness of the challenges faced by cocoa farmers can result in greater support for increased share paid to farmers. The example given by Interviewee 10, where farmers *"send their child to school"* because they could now afford it, illustrates the potential long-term benefit of ECBMs. These models can foster more ethical and sustainable consumption patterns, even among younger, perhaps less financially established consumers (including farmers). By focusing on education and ethical engagement, ECBMs can increase consumer willingness to raise the share paid to farmers, leading to better outcomes for cocoa farming families and communities in the long run.

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[3] Permission to share the video was obtained from the author, van de Velde (2018, 2021), and the link (https://vimeo.com/139873232) was shared with respondents, who were requested to watch from 9:10 to 9:52.

4.5.　Consumers' understanding of entrepreneurship

Interviews reveal clear views of entrepreneurship within ECBMs. According to Interviewee 4:

"I would define entrepreneurship as the concept and practice of identifying and building opportunity, almost always through partnerships to address a particular problem or need. It doesn't have to be a business venture. It can be any response whereby a person or group uses their network, their ingenuity, their vision, their resources to make something where there wasn't something before – something necessary and helpful."

Interviewee 10 highlighted the asymmetric pricing power held by buyers and described farmers as pioneering agents of value chain transformation. Interviewee 7 articulated the notion of "creating societal value," explaining that entrepreneurship should create value for the community in addition to firm profit.

Farmers may wish to adopt circular practices but face high upfront costs and limited finance. Consumers may prefer ethically produced cocoa but are constrained by immediate liquidity, even when expecting higher future income. Thus, expectations and resource access jointly shape behaviour. According to the AIH, higher-income consumers are more likely to support entrepreneurial initiatives, while lower-income consumers will be more price sensitive. The PIH suggests that consumers who believe in the long-term societal benefits of funding entrepreneurial circular ventures might be willing to pay more, even if their current income is limited. The LCH would assert that more financially secure consumers (middle-aged) are more likely to support ECBM initiatives, as they have more disposable income and can prioritize long-term value over immediate financial constraints.

4.6.　Circularity's role in reducing economic poverty

Most interviewees agreed that circularity is designed to reduce waste. However, there was a lack of agreement on whether it can reduce economic poverty. Interviewee 3 claimed:

"Circularity will largely be implemented to drive resource efficiency, and to reduce waste to drive more profit. Circularity will not necessarily be introduced to provide greater value to all people within the supply chain."

Interviewee 3's view asserts that circularity might be exploited by powerful stakeholders for profit, without genuinely improving the lives of economically disadvantaged stakeholders. Interviewee 5 also showed reservations, contending that thinking about circularity in terms of the cocoa value chain could be problematic *"because cocoa is produced in one place and consumed somewhere else."*

Interviewee 5's viewpoint could be interpreted either as a complete dismissal of circularity in the cocoa value chain or a challenge with the purpose of strengthening the resolve of a budding concept (González-Sánchez et al., 2020; Puntillo et al., 2021). The latter is more likely, given that the 3 P's framework of the circular economy – People, Policies and Places – devotes significant discussion to location-specific contexts (Lüdeke-Freund et al., 2018; OECD, 2020b; Winterstetter et al., 2021).

4.7.　Leveraging ECBMs for cocoa farmers

Interviewees proposed several ECBMs to advance circularity and secure a living income for cocoa farmers. They emphasized valorising cocoa by-products to create new revenue streams and diversify earnings. Interviewee 9 proposed using cocoa pod shells as compost and fruit pulp to produce cocoa-based juice. Interviewee 10 suggested extracting pectin and potassium carbonate from the pod to make jams, juice, vinegar, and other innovative products. By-products that were previously discarded could be marketed, adding value and reducing risk around the farmer's expected income. These examples show how ECBMs can turn waste into income while increasing the value harnessed from the entire pod.

Interviewee 10 also noted that powerful stakeholders (e.g. multinationals) could help build markets for by-products, provided prices are fair. A start-up producing lab-grown chocolate further illustrates the potential for circular transformation: it reduces food miles, deforestation, and forced child labour. Together, these examples indicate a pathway to a fairer cocoa value chain.

Finally, Int 12 emphasized the importance of a recent development in Côte d'Ivoire. Between 2020-2025, the newly adopted 'code producteur' system has enabled progress in monitoring sustainable agricultural practices. This innovation could integrate sustainability metrics aimed at ensuring fair compensation for farmers. As will be shown in the Discussion, this presents an opportunity to integrate a new conceptual framework.

5. Discussion

5.1. Circularity's role

The perspective articulated by Interviewee 3 – that "*circularity will not necessarily be introduced to provide greater value to all people within the supply chain*" – provides a particularly valuable critique (Piketty, 2017; Smith, 2008) of how circularity might be applied to cocoa production. While the circular economy literature highlights the potential of circularity to reduce waste – as posited by Kirchherr et al. (2017, 2023) and Morseletto (2020) – it does not address whether such models would also improve economic outcomes for farmers (Dumbrell et al., 2020) if introduced into cocoa value chains. The interviewee's observation therefore draws attention to an important gap: even if circular practices were adopted in this context, their capacity to reduce poverty is not yet clear and would benefit from further exploration.

According to Keynes (2018), a consumption-driven economy requires stable income levels and government intervention to maintain aggregate demand. This can indirectly reduce poverty risk by ensuring a minimum level of economic security. The intentionality behind Keynesian government intervention could be replicated in the implementation of ECBMs. More specifically, to reduce poverty, circular models could integrate waste reduction with clear social and economic empowerment objectives for farmers. This calls for intentional policies (Ingram, 2025) that align circularity with poverty reduction goals, ensuring that those most affected by economic hardship can benefit from ECBMs. It is proposed that such policies be informed by the FSF (please see section 5.3.).

5.2. Leveraging ECBMs

The ECBMs proposed by the interviewees, such as utilizing cocoa pod by-products to create compost, fruit juice, or other value-added products, could play a major role in increasing cocoa farmers' competitive advantage (Porter, 2008) and incomes (Traoré & Dzifa Torvikey, 2022). The effect would be considerable in Ivorian value chains because cocoa production plays a central role in Côte d'Ivoire's social and economic development (Coulibaly & Erbao, 2019). Furthermore, agricultural exports contribute significantly to the region's balance of payments (Giller, 2020). Through the lens of the AIH, introducing additional income streams via ECBMs could impact current income, leading to increased consumption and improved quality of life for farmers (Maslow, 1943). According to the PIH, an ECBM that ensures stable, long-term income from diversified by-products could help provide a more predictable financial future, allowing farmers to better plan their consumption and savings based on their permanent income. Based on the LCH, by stabilizing income over time, ECBMs could enable cocoa farmers to participate in long-term financial planning. This would allow farmers to smooth their consumption throughout their lives, even in the face of unpredictable income from cocoa farming alone. Overall, leveraging ECBMs in the cocoa value chain can enhance income stability and create a pathway toward sustainable consumption for farmers. This would ultimately lead to improved economic welfare and poverty alleviation. These findings align with the overarching objectives of circular economies: to create sustainable, long-term income streams whilst addressing societal needs (Erdiaw-Kwasie, 2023).

However, while ECBMs promise to enhance farmers' income stability, they would need to be designed with clearly integrated value chain fairness objectives to overcome implementation challenges (Försterling et al., 2023). Thus, if ECBMs are to create a new cocoa business model that truly improves farmer livelihoods, it is proposed that they be leveraged to full effect by following the Fair Score Framework.

5.3.   Introducing the Fair Score Framework

The research extends current knowledge of the cocoa value chain by introducing a new conceptual framework: the Fair Score Framework (FSF). The FSF has been developed directly from insights gained from this research. It is designed to measure the fairness of value chains, and not only in cocoa. The FSF is inspired by two distinct frameworks: the Nutri-Score framework (Hau & Lange, 2023; Peters & Verhagen, 2022), and the Circularity Scoreboard for cities developed by the Organisation for Economic Cooperation and Development (OECD, 2020a, 2022).

The FSF assigns a level of fairness to a product. A product's "Fair Score" out of 100 is assigned a rating. The rating ranges from "A" to "B" to "C" to "D" to "E", with "A" being most fair and "E" being least fair, on a relative scale. The FSF letter grades and colours could be set up as shown in Table 5.

Table 5. Tabular reference for Fair Score ratings and colour codes

Fair Score (out of 100)	Fair Score rating (from A to E)	Colour code	Example
73-100	A	Green	Chocolate liquor (cocoa mass) Fair Score: 81
62-72	B	Chartreuse	Cocoa nibs Fair Score: 65
51-61	C	Yellow	Cocoa butter Fair Score: 57
40-50	D	Orange	Cocoa powder Fair Score: 43
0-39	E	Red	Chocolate bar Fair Score: 23

A Fair Score between 73-100 (inclusive) is categorized as an "A" rating. A Fair Score between 62-72 (inclusive) is categorized as a "B" rating. Each letter grade is accompanied by a corresponding colour. The colour green for "A", chartreuse for "B", yellow for "C", orange for "D", and red for "E". Using coloured letter grades allows for improved consumer interaction at point of sale (Corvellec et al., 2022).

5.4.   Contribution to practice

The FSF displays value chain fairness to consumers in the form of a user-friendly front-of-pack label. For any given value chain, the Fair Score is calculated using ten criteria, supported by literature. For example, a value chain has scored a total of 83 out of 100 points, which places in the "A" (Green) category (see Figure 3).
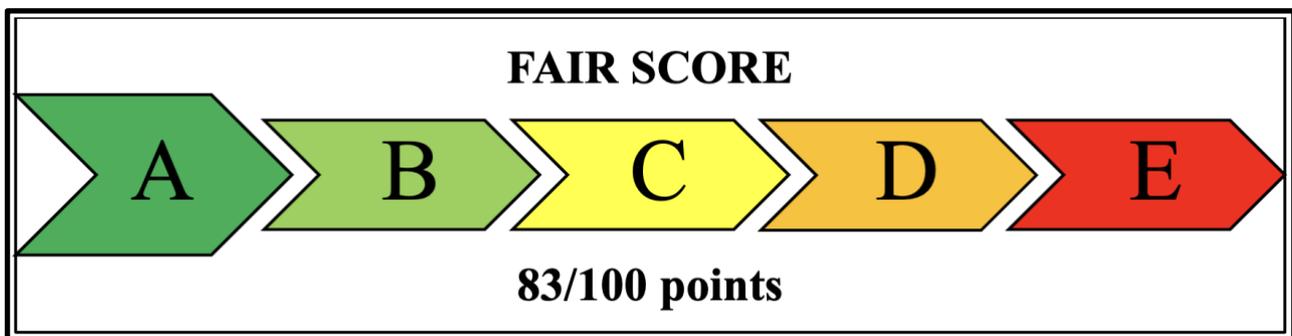

Figure 3. Visual representation of an "A" (Green) grade value chain using the Fair Score Framework

The score of 83 points out of 100 would be awarded using table 6.

Table 6. Tabular example of an "A (Green)" grade value chain using the Fair Score Framework

Criterion	Indicators based on research	Score out of 10
Criterion 1	Indicator 1.1.	8
Criterion 2	Indicator 2.1. Indicator 2.2.	8
Criterion 3	Indicator 3.1. Indicator 3.2.	7
Criterion 4	Indicator 4.1.	9
Criterion 5	Indicator 5.1. Indicator 5.2.	9
Criterion 6	Indicator 6.1. Indicator 6.2.	9
Criterion 7	Indicator 7.1.	8
Criterion 8	Indicator 8.1. Indicator 8.2. Indicator 8.3.	7
Criterion 9	Indicator 9.1. Indicator 9.1.	9
Criterion 10	Indicator 10.1.	9
Total score out of 100		83
Fair Score letter A to E and colour code		A (Green)

Table 6 showcases an "A" (Green) grade value chain. In the following paragraphs, the FSF is used to measure the fairness of the modern-day Ivorian CVC, using criteria and indicators developed from the research findings.

After careful study, the modern-day Ivorian CVC would yield 23/100 points, a rating of "E" (Red), as shown in Figure 4.
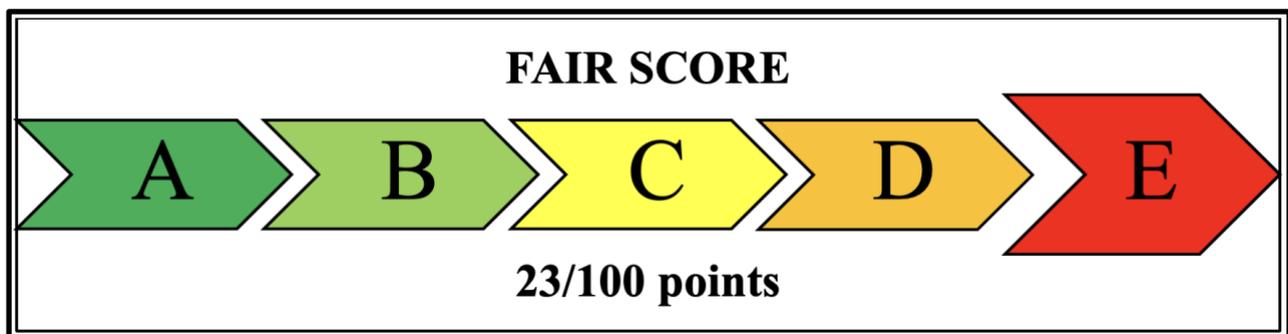
Figure 4. Visual representation of the Fair Score Framework applied to the modern-day Ivorian cocoa value chain

The rating of 23/100 in Figure 4 has been calculated using the specific criteria and indicators shown in the first two columns of Table 1. The scores in the third column are estimations based on the knowledge gained from the research. The individual scores per indicator were estimated as follows: Farmer's pay (1), Transparency (2), Circularity (1), Forced child labour (1), Excessive deforestation (1), Entrepreneurial Circular Business Models (2), Individual's full potential (1), Sustainable Development Goals (2), Demand (9), and Common good (3). The total Fair Score of 23 out of 100 equates to a Fair Score letter and colour of E (Red).

5.5.   Contribution to policy

It is proposed that the operationalisation of the FSF be based on the goals, targets, and indicators of the United Nations Sustainable Development Goals (UN SDGs). For example, FSF criterion 1 aligns with Goal number 1, "no poverty," which includes:

- Target: "by 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day" and,
- Indicator: "proportion of the population living below the international poverty line by sex, age, employment status and geographical location (urban/rural)" (United Nations, 2025).

The operationalisation of the FSF, aligned with the SDGs, presents an opportunity to enhance consumer awareness and foster the purchase of products from fairer value chains, and not only in cocoa. If successful, the FSF could contribute to achieving the SDGs by the 2030 deadline.

As outlined in section 4.7., the newly adopted 'code producteur' system in Côte d'Ivoire has enabled progress in monitoring sustainable agricultural practices. It is the ideal policy and time for the FSF to dovetail with. This would effectively consolidate the link between the UN SDGs and frameworks already present locally in the cocoa value chain.

5.6.   Contribution to understanding

An important constraint in remote regions of Côte d'Ivoire that impedes sales of cocoa beans at the proper 'prix bord champ' is the severe lack of cash (i.e. liquidity). This stems from limited access to financial infrastructure, including both banks and ATMs, and a general lack of cash flow in rural areas. Consequently, many farmers are unable to negotiate the right price for their beans, often accepting lower payments due to immediate financial pressures (Laven, 2010) or limited access to markets. This issue increases the economic vulnerability of small-scale farmers (Anker & Anker, 2017) and represents a significant challenge in the sustainable development of the cocoa value chain. The lack of liquidity precludes the fair compensation for farmers. This constrains farmers' capacity to reinvest in sustainable practices that benefit the broader community (OECD, 2020a, 2022, 2023; Sachs et al., 2019).

6. Conclusion

6.1.   Research problem

There is no actionable framework that integrates circular economy approaches within the cocoa value chain to effectively address farmers' living incomes. Côte d'Ivoire is a world leading cocoa producer, and yet, most Ivorian cocoa farmers fail to earn living incomes.

6.2.   Study aim

To develop a new conceptual framework that can be used to address the living income problem in the cocoa value chain.

6.3.   Approach adopted

A qualitative approach to examine how ECBMs could be leveraged so that cocoa farmers in Côte d'Ivoire achieve circularity and maintain living incomes. Insights were gleaned from farmers, consumers, and interviewees.

6.4. Main findings and implications

Farmer perspectives (n=215): asked whether circularity would enable living incomes (1 = not at all; 10 = very much), farmers' responses ranged from 1 to 10 (median = 5; mean = 4.8; SD = 2.31). This dispersion indicates neither broad endorsement nor rejection. Rather, farmers view circularity as one solution among many for addressing a structurally complex income problem.

Consumer behaviour (n=212): in a paired-samples t-test across the UK, Germany, France, the USA, Switzerland, and the Netherlands, the share paid to farmers rose by 7.41% after respondents viewed an informational video on the Ivorian CVC. Reliability was acceptable across datasets, with Germany (Cronbach's $\alpha = 0.713$) and the pooled sample ($\alpha = 0.790$) the strongest. These results suggest that educating consumers can increase willingness to support fairer payments to farmers.

Expert interviews (n=12): Interviewee 3 cautioned that circularity, while effective at reducing waste, may not reduce economic poverty without an explicit living income objective. Interviewee 5 questioned the fit of circularity given localized production versus global consumption of cocoa-based products. By contrast, Interviewees 9 and 10 identified concrete ECBM pathways: valorising cocoa by-products (e.g. pod shells to compost; pulp to juice, jams, vinegar) to diversify revenue, and leveraging purchasing commitments from powerful stakeholders (e.g. for pectin) at fair prices to stabilize income.

Overall, the potential of ECBMs is substantial but conditional. Farmers' uncertainty, structural constraints in the value chain, and the risk of goal drift toward profitability all point to the need for intentional policies that integrate living income and fairness criteria from the outset. Anchoring ECBM decisions in the FSF (see section 5.3) offers a route to ensure that circularity contributes to income stability rather than merely to waste reduction. Over time, successful implementation of ECBMs using the FSF could compound into improved education, better health outcomes, and sustained living incomes in farming communities.

6.5. Limitations

The farmer questionnaire (n=215) was distributed in the San-Pédro region. While this is one of the most important cocoa-producing areas of Côte d'Ivoire, restricting data collection to one region may limit generalisability. Collecting data from additional regions - such as Nawa and Haut-Sassandra - may provide further relevant insights and strengthen external validity. Sampling farmers in Côte d'Ivoire alone means the findings may not be representative of farmers in other cocoa-producing countries with different social and economic factors.

A similar limitation applies to the consumer questionnaire (n=212). Consumers participated from universities across six countries, which provided access to a diverse but not necessarily representative group of respondents. This may limit the extent to which their views reflect broader consumer behaviour.

This limitation also extends to the interviewees (n=12), whose perspectives – while valuable – may not capture the full range of views held by actors across the cocoa value chain.

Because the questionnaires and interviews were completed at a single point in time and not over a longer period as in longitudinal studies, it is impossible to observe changes over a longer period. Finally, this research focuses on the cocoa value chain, which may limit the extent to which the findings apply to other sectors.

6.6. Contribution to knowledge

The research culminated in the development of a new conceptual framework – the Fair Score Framework – which measures value chain fairness.

6.7. Future studies

The FSF is designed both to guide consumers toward fairer value chains and to improve farmers' livelihoods. If the FSF successfully supports consumers to purchase from fairer value chains, there is potential for increased success in achieving the 2030 SDGs on time. Building on this study, two avenues for future research emerge:

1. Methodological extensions: expand geographic coverage beyond San-Pédro (e.g. Nawa, Haut-Sassandra) and raise per-country samples in the Netherlands, Switzerland, and Belgium to n > 30.
2. Conceptual extensions: examine additional lenses for implementing circularity within the FSF: the Efficient Market Hypothesis (Ali et al., 2021), the Time Value of Money (Scudder et al., 2022), and the Fisher Effect (Schulze, 2022).

Given these research avenues, the following research questions are proposed:

a. How can the incidence of a 'Tragedy of the Commons' be reduced within the circular economy?
b. How can commercial confidentiality be preserved while improving VCT?
c. How might growth theories introduced in the Dasgupta Review be used to achieve the Sustainable Development Goals?
d. In addition to cocoa, why and how might the FSF be applied to other sectors?

Data availability Datasets from this study are available from the corresponding author upon reasonable request.

Declarations

Competing Interests The author declares no competing interests.

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