

# EVALUATING THE SUSTAINABILITY OF SUGAR VALUE CHAIN: EVIDENCE FROM VIETNAM

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## ABSTRACT

*This paper investigates the sugar value chain in Vietnam and evaluates its sustainability using integrative indicators based on the Triple Bottom Line (TBL) approach. A set of 27 indicators were used in our survey of key stakeholders in the sugar value chain of Vietnam. After 2 months, we received 482 questionnaires and retained 473 valid responses. Our findings show that there are still many challenges for the Vietnamese sugar value chain to grow sustainably. Thus, we proposed some suggestions to enhance the sustainability of the Vietnamese sugar value chain.*

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## 1. INTRODUCTION

In recent decades, increased worldwide competitiveness and decreased commodity prices have led to agriculture sectors pursuing value chain possibilities to boost profitability and sustainability (Boehlje et al., 1999; Martin 2001; Labuschagne et al. 2005). Martin (2001) highlights other drivers, including the industrialisation of agriculture as farming shifts from a rural lifestyle to an agribusiness sector with a value chain mentality. Sugar industries around the world are no exception. The long-term sugar price trend has been downwards despite the costs of production generally has been increasing. Increased competition from new potent sweeteners as sugar substitutes may put more pressure on sugar pricing (Higgins et al., 2007). Furthermore, sugar production (per hectare) has stayed stable or decreased in many established sugarcane-growing regions during the last three to five decades (Meyer and Van Antwerpen, 2001; Garside et al., 2001). These challenges have resulted in a greater emphasis on value chain solutions to boost profitability.

In Vietnam, the sugar industry is essential and plays a vital role in agriculture-based industries. In the last 5 years, the Vietnamese sugar industry has suffered severe losses due to the impact of the unequal business

environment. Over the years, the devaluation of sugar from Thailand has found many ways to enter the Vietnamese market, causing the domestic sugar price to drop below production costs. As a result, the local sugar factories are forced to sell sugar below the production cost, leading to severe damage to the sugar industry in Vietnam. In addition, climate change is also causing difficulties for the Vietnamese sugar industry. Prolonged drought, and quick drying of sugarcane lead to reduced weight and quality of sugarcane in the last months of harvest and high transportation costs. Processing and taking advantage of by-products after processing sugar are not much. In other words, the Vietnamese sugar industry is in a precarious stage.

As a result, there is a quest to maintain the sustainability of the Vietnamese sugar industry. In this regard, it is essential to explore and evaluate the sustainability of the sugar value chain in Vietnam and raise some suggestions to improve the value chain.

## 2. LITERATURE REVIEW

### 2.1 Value chain and sugar value chain

The value chain concept was developed and popularized in 1985 by Michael Porter, in "Competitive

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Advantage,” a seminal work on the implementation of competitive strategy to achieve superior business performance. Porter (1985) defined value as the amount buyers are willing to pay for what a firm provides. He conceived the “value chain” as the combination of nine generic value-added activities operating within a firm – activities that work together to provide value to customers. Porter linked up the value chains between firms to form a Value System. However, in the present era of greater outsourcing and collaboration, the linkage between multiple firms’ value-creating processes has more commonly become called the “value chain.” As this name implies, the primary focus in value chains is on the benefits that accrue to customers, the interdependent processes that generate value, and the resulting demand and funds flow that are created. Effective value chains generate profits.

In the agriculture sector, the value chain approach provides a systematic process to improve market linkage for farmers (Ferris et al., 2014). It provides a framework for identifying key constraints and considering appropriate solutions (Orozco-Romero et al., 2020). These constraints and solutions require a coordinated response by different stakeholders in the chain, which necessitates trust and a willingness to collaborate (USAID, 2012). Through the value chain approach, one can understand the farmer-trader relationship, power dynamics, and the distribution of benefits. According to Rota and Sperandini (2010), value chain analysis is essential to an understanding of markets, their relationships, the participation of different actors, and the critical constraints that limit the growth of agricultural production and, consequently the competitiveness of smallholder farmers. These farmers currently receive only a small fraction of the ultimate value of their output. Sugar industries worldwide are primarily “push chains”, where sugarcane is pushed through the chain to produce raw sugar with minimal product differentiation and sold at market value as a bulk commodity. A general sugar value chain consists of growing, harvesting, cane transport, mill processing, sugar transport, and storage/shipping/marketing sectors.

## **2.2 Sustainability of the sugar value chain**

The sustainability of the sugar value chain has been of primary concern for researchers and practitioners in recent decades. As a result, various issues related to the value chain have been discussed. For example, Higgins and Laredo (2006) explored the Australian sugar industry and proposed an analytical framework to model the components involved in the harvesting and transportation of sugar cane products in the value chain. Research by Higgins and Laredo (2006) showed that there are several key points for improvement, such as rearranging the harvesting process or streamlining the transportation infrastructure that will help increase the return value for stakeholders.

Similarly, Archer et al. (2008) conducted a review of the studies on the sugar value chain and elucidated the challenges in this research topic. These authors compared

the sugar industry of Australia and South Africa, thereby pointing out solutions to develop the sugarcane value chain that not only include technical solutions but also need collaborative participation throughout the chain, and regularly change in a disruptive way. Accordingly, the sugar value chain should be developed in a lean and flexible direction.

Kalinda and Chisanga (2014) studied the sugar value chain in Zambia and pointed out the opportunities and challenges for the development of the sugar industry. The specialty of the Zambian sugar industry is that it is a monopolistic industry with only one business, contributing 4% of the country’s GDP and 6% of the country’s total exports.

Perlata and Navarrete (2017) researched the problem of creating shared value in the sugar industry and offers a model that proposes 6 steps to choose a strategy to create shared value in the enterprise’s value chain. According to these two authors, shared values are reinforced through supplier development.

In another study, Manda et al. (2020) explores the factors influencing the participation of farmers in the sugarcane value chain and examines the preconditions required to secure the benefits and forms of participation. suitable for local groups in the chain.

Srichanthamit and Tippayawong (2018) designed and developed a set of criteria for evaluating value chain performance for the sugar industry based on value chain management theory and case studies. In this study, Srichanthamit and Tippayawong (2018) use a quality function development (QFD) tool to integrate with value chain activities and find success factors with different evaluation weights together. This set of indicators is applied to the case study of a sugar factory to assess its relevance to practice. Research results show that this set of criteria can be used by sugar mills for internal evaluation.

In general, researches on the value chain in the sugar industry in the world have focused mainly on value chain tools to assess the current situation of the value chain and find solutions to improve the performance of the sugar industry. A few studies have addressed the value chain evaluation criteria, but none have directly addressed the sustainability of the sugar value chain. Similarly, in Vietnam, studies on the sugar industry have been conducted, but in-depth studies on the sugar value chain and its sustainability are not available.

## **2.3 Evaluating sustainability of a value chain**

The sustainability of the value chain can be expressed simultaneously along three dimensions: economic, social and environmental or triple bottom line (profit, people and planet) (Gebre & Rik, 2016). On the economic dimension, an existing or proposed upgraded value chain is considered sustainable if the required activities at the level of each actor or support provider are commercially profitable. On the social dimension, sustainability refers to socially acceptable outcomes in terms of the distribution of the benefits and costs associated with increased value creation. On the environmental

dimension, sustainability is determined largely by the ability of value chain actors to show little or no negative impact on the natural environment from their value-adding activities; where possible, they should show a positive impact (Neven, 2014).

Sustainability indicators are particularly hard to define and measure. The basic problem is that sustainability only occurs in the future while the indicators are measured in the present (USAID, 2012). Although the three sustainability dimensions (social, environmental, and economic) are treated individually here for clarity, in practice they overlap (USAID, 2012). Once the core processes of the value chain are mapped, indicators must be associated with each chain, for the three sustainability dimensions. The indicator selection depends on the level of the organization and the type of activities (Moreno & Salgado, 2012).

Previous conventional life cycle assessment models in the past often focused on sustainability indicators such as raw materials, energy, emissions, etc. These indicators are chosen because they are directly related to all stages in the value chain and can be quantified. However, it is not simple to assess the socioeconomic impact of the value chain of a specific product. In such a context, we propose that there is a need for multiple methods of measuring socioeconomic criteria to describe the relationship between products and socioeconomic impacts, which can be successfully integrated into the traditional analysis framework. In our classification, economic and social indicators are divided into two categories: additive and descriptive.

The additive indicators must meet two criteria: (1) they can be measured quantitatively, and (2) they are related to production volume so that they can be cumulative throughout the value chain. For example, production cost, labor cost, and value added per unit. In addition, some socioeconomic indicators to measure sustainability that is widely considered fail to meet the requirement to be additives because they are not directly related to production. This classification is suitable for measuring social and environmental aspects (Kruse et al., 2009). Descriptive indicators can be divided into general and specific indicators based on the viewpoints or the different social contexts. The general indicators are often used to describe widely accepted social values, such as working conditions in relation to the minimum wage, social benefits, number of working hours per week, the gender ratio, etc. On the other hand, specific indicators are those factors that cannot be widely applied in any industry. These indicators focus on measuring the economic, social, and environmental impact of a specific product or procedure. They are qualitatively or quantitatively measured, but their comparison ability of these indicators are limited to similar production system. For example, the impact of pesticide use on workers can become a major concern in the sugar industry but not in the fishery industry. From a sustainability viewpoint, specific descriptive indicators allow us to focus on sustainability issues related to a particular product.

### **3. METHODOLOGY**

#### **3.1 Sample and procedures**

The primary data collection process is divided into two phases. At the first stage, we asked 57 experts and researchers who have grasp of knowledge of Nghe An sugar value chain to assess the suitability and feasibility of 51 triple-bottom-line-based indicators that were gathered from previous research including Balkau and Sonnemann (2010), Pettit et al. (2019), Yakovleva (2007), Fearne, Martinez and Dent (2012), Warhurst (2002), Hassini (2015), Tarekegn et al. (2020). The sample consisted of 50% women and 46.4% men. The age of survey participants ranged from 28 to 60 years, with 91% of an age between 28 to 57. University or higher education accounted for 73.2% participants. This percentage would improve the quality of the evaluation results. Moreover, the percentage of respondents who know the value chain accounts for 83.9%, which is also another indicator of the quality of the responses.

27 out of 51 indicators are judged to be relevant and feasibility, with the percentage of raters agreeing or completely agreeing over 75%. For example, the item "Sugarcane farmers take part in training programs on planting and managing arable land" was assessed by 83.6% of experts as an appropriate indicator. The Krippendorff's Alpha index of all the 27 indicators is greater than 0.667 (Landis & Koch, 1977), indicating consensus in the expert responses about the relevance and feasibility of the criteria. 24 indicators were excluded because they are not relevant to the condition of Nghe An sugarcane industry or not feasible to measure their impact. For example, the indicator "Discrimination between men and women in the sugarcane industry" may be not a suitable criterion for measuring sustainability. Particularly, the topographical condition for sugarcane cultivation are sloping and scattered in Nghe An, which does not create favorable conditions for mechanization in sugarcane planting and harvesting activities. As a result, the disproportion between male and female labor is inevitable.

In the second stage, the questionnaires which consist of the 27 selected indicators in the first stage were sent out to a broader range of stakeholders, such as farmers, sugar mills, cooperatives, suppliers, distributors and public administrators to measure the sustainability of Nghe An sugarcane value chain

With the goal of evaluating the sustainability of sugar value chain in Vietnam, we decided to chose Nghe An province as an representative sample because the province demonstrates the average typical features of various sugar chain regions in Vietnam. In the crop year 2021-2022, the total area of raw sugarcane in Nghe An reaches 19,223 hectares, concentrated in the following districts: Quy Hop 4,961 hectares; Tan Ky 3,171 hectares; Nghia Dan 7,600 hectares; Quy Chau 1,158 hectares; Quynh Luu 936 hectares; Anh Son 449 hectares. The average yield of sugarcane is nearly 61.0 tons/ha; output reached 1,173,000 tons, serving 3 sugar

processing factories with a total designed capacity of 15,500 tons of sugarcane/day.

To identify the target population, we gathered contact information of the sugar value chain's stakeholders through the support of officials from Nghe An Department of Agriculture and Rural Development. We randomly selected 987 stakeholders, including farmers, employees in sugar mills, cooperatives, suppliers, distributors and public administrators, and invited them to participate in both our web-based survey via email and paper-pencil-based survey. We received 482 questionnaires, which corresponds to a 48.8% response rate. After dropping questionnaires with incomplete data (missing data greater than 5%) and reckless responses, we retained

473 responses in total. Our sample consists of ten groups, including cooperative farmers (N=101), individual farmers (N=55), dealers (N=21), retailers (N=10), cooperative leaders (N=98), sugar mill employees (N=112), transport, local government officials (N=20), agricultural advisors (N=20), transporters (N=26), material and tool suppliers (N=10). The proportion of the sample represents the true proportion of the stakeholders in Nghe An sugar value chain. The education of survey respondents were primarily high school and vocational degree (66.6%). Age mostly ranges from 28 to 47 years old (72.1%) and the majority of respondents were males (71.7%).

### 3.2 Measures

Measures used in this study were adapted from established scales. We used multi-item scales based on 5-point Likert scales from "1" (strongly disagree) to "5" (strongly agree), unless otherwise stated.

We captured the economic dimension through eight items from Yakovleva (2007) and Hassini (2015). The items of the scale ask respondents to evaluate how sustainable the economic indicators are. A sample item is "Income from the value chain ensures essential needs" with a five-point Likert scale ("1" = "Strongly disagree", "5" = "Strongly agree"). Cronbach's alpha of the scale is 0.86.

The social aspect was measured using twelve items taken from Mayer (2008), Labuschagne et al. (2005). The items indicate how sustainable the social criteria of the sugarcane value chain are, and they are coded on a five-point Likert scale ("1" = "Strongly disagree" to "5" = "Strongly agree"). A sample item, for example, is "workers are guaranteed safety in the workplace". The scale has a Cronbach's alpha of 0.90. The environmental aspect was measured using seven items collected from Darmawan et al. (2014), Gebre and Rik (2016). The items indicate how sustainable the environmental criteria of the sugarcane value chain are. A sample item is "Stakeholders in the value chain using renewable energy sources". The scale has a Cronbach's alpha of 0.76.

## 4. RESULTS AND DISCUSSIONS

### 4.1 Preliminary analysis

We conducted confirmatory factor analysis (CFA) on all multi-item scales using R to validate the scales. We conceptualised 'economic', 'social', 'environmental' as first-order factors, which can be freely correlated. We used Chi-square statistics and practical fit indices to evaluate model fit. In particular, standardized root-mean-square residual (SRMR) with a cut-off value of 0.08, root-mean-square error of approximation (RMSEA) with a cut-off value of .06, and comparative fit index (CFI) with a cut-off value of 0.95 were used as evidence of good model fit (Hu & Bentler, 1998). After deleting 6 items with a modification index greater than 30, the results of this analysis indicate good model fit:  $\chi^2 (186) = 567.556$ ; CFI = .951; SRMR = .0049; RMSEA = .061 (see Table 1 in the Appendix). Furthermore, all standardized loading estimates are higher than 0.50 (Hair et al. 2010) (see Table 2 in the Appendix), average variance extracted (AVE) and composite reliability (C.R) of all the factors in the model greater than 0.50 and 0.70 respectively are indicators of convergent validity. Discriminant validity was tested by a more rigorous test which requires the AVE of each of the latent constructs to be higher than the highest squared correlation with any other latent variable in the model (Fornell & Larcker 1981). These conditions were met suggesting discriminant validity (see Table 3 in the Appendix).

### 4.2 Analysis of sustainability indicators

To evaluate the sustainability of the sugar value chain in Vietnam, we calculate the mean value of each indicator by 10 groups of respondents and sum up in total of 473 respondents (see Table 4 in the Appendix).

As shown in Table 4, the mean values of 6 economic indicators range from 3.19 to 3.55 (higher than 3.00). Thus, we might conclude that the sugar value chain is not sustainable in terms of economic aspects. Among the 6 economic indicators, logistics cost (Q15) has the highest mean value of 3.55 and labor cost (Q13) has the lowest mean value of 3.19. Other economic indicators have a mean value of around 3.50. Thus, it is implied that the Vietnamese sugar value chain is facing many challenges to be economically sustainable. This finding is attributed to the fact that the Vietnamese sugar industry has been severely impacted by fierce competition from illegally imported sugar from Thailand and other issues such as drought, flood, and diseases. As a result, sugar companies have to sell sugar at an extremely low price, even lower than the production cost. In turn, they pay very little to farmers who grow the sugarcane. Therefore, farmers are disappointed and do not want to commit to the sugar mills to grow sugarcane and maintain the long-term input supply. This finding is typical for the case of Vietnam. Regarding the social aspect, 11 indicators are retained in our measurement to evaluate the sustainability of the sugar value chain. Table 4 reveals that the mean values of social indicators range from 3.66 to 3.92. Notably, 8 out of 11 indicators have mean values higher than 3.80,

indicating that all respondents agree that the sugar value chain is socially sustainable. Some indicators in this measurement achieve quite a high mean value (over 3.80), such as “tax payment to the government budget” (Q21), “clear regulations for recalling defective products” (Q35), “participating in training farmers on sugarcane planting and relevant skills” (Q36). The mentioned activities are taken by the sugar mills and are related to different stakeholders in the value chain, including the government, consumers, and the local community. Therefore, it is implied that sugar mills play a critical role in socially improving the value chain’s sustainability. In the case of our study, Nghe An province is a big area where the living condition and average income of the civils are still low. Thus, the appearance of big and modern sugar mills is very critical to the sustainable growth of the industry and the region.

In terms of the environmental aspect, we have 4 indicators in the measurement, of which the issue related to “improving the fertility of the soil” (Q56) achieves the highest mean value of 3.91. The lowest mean value of the environmental indicator is 3.66 (Q40), which is “using recycling packaging”. These findings are in line with some previous studies of the food value chain, such as Yakovleva (2007), or the banana value chain of Gebre et al. (2020).

In addition, it is notable in our study that among the 10 groups of respondents, dealers and retailers tend to rate most indicators at a higher value than other groups, showing that they are very optimistic about the sustainability of the Vietnamese sugar value chain. On the contrary, agricultural advisors and cooperative farmers always give lower scores to all indicators than other groups. This finding implies that agricultural advisors and collective farmers are less optimistic about the sustainability of the Vietnamese sugar value chain than the remaining respondents. The doubt of these two groups regarding the sustainability of the sugar value chain might be explained by their deep engagement in the value chain and their daily exposure to the activities of sugarcane growing. Furthermore, these two groups are believed to be more knowledgeable of the sugar value chain than the dealers and retailers.

## References:

- Archer, A. A., Thorburn, P., Hobson, P., & Higgins, A. (2008). Evaluating alternate strategic options for agricultural value chains. *Journal on Chain and Network Science*, 8(2), 131-141.
- Boehlje, M. D., Hofing, S. L., & Schroeder, R. C. (1999). Value chains in the agricultural industries. *Staff Paper*, (99-10).
- Balkau F., & Sonnemann G. (2010). Managing sustainability performance through the value-chain. *Corporate Governance*, 10(1), 46 – 58.
- Darmawan, M. M., Putra, M. A., M., M. P. I. F., & Wiguna, B. (2014). Value chain analysis for green productivity improvement in the natural rubber supply chain: a case study. *Journal of Cleaner Production*, 85, 201–211. DOI: 10.1016/J.JCLEPRO.2014.01.098
- Fearne, A., Martinez, M. G., & Dent, B. (2012). Dimensions of sustainable value chains: implications for value chain analysis. *Supply Chain Management: An International Journal*. 1-20.

## 5. RECOMMENDATIONS AND CONCLUSION

In the present study, we evaluate the sustainability of the Vietnamese sugar value chain from the stakeholder perspective. We found that the sugar value chain seems to be more sustainable in terms of social and environmental aspects than economic aspect. From our findings, we suggest that some key stakeholders should be more active in promoting the sustainability of the value chain, who are the sugar mills, the local government and the supporting organizations in the industry. For example, financial shortage is one problem for farmers to maintain their growing and harvesting process. Thus, to enhance the economic sustainability of the value chain, it is essential to prioritize the loan for poor farmers so that they can invest in sugarcane growing. Banks and sugar mills should joint hand to support farmers access the loan. In addition, we strongly recommend sugar companies should also take their responsibility in promoting the sustainability of the sugar value chain. Sugar companies participate in many phases of the value chain so they have wide sphere of influences on the farmers, the input suppliers, the distributors. Thus, they will be able to guide farmers and encourage them to grow sugarcane and commit a to buy sugarcane from farmers at a stable and profitable price.

Furthermore, local government should admend the policies to strengthen the relationship among farmers, sugar mills, dealers, retailers and other stakeholders.

This study has some limitations. Sample size is small so that the research results might not be generalized for the whole sugar industry in Vietnam. Moreover, we have not yet applied in-depth interview method to further explore the reasons for unsustainable issues. Thus, we suggest that future study should expand the survey to other provinces in Vietnam and employ more qualitative methods.

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- Ferris, S., Robbins, P., Best, R., Seville, D., Buxton, A., Shriver, J., & Wei, E. (2014). Linking smallholder farmers to markets and the implications for extension and advisory services. *MEAS Brief*, 4(10), 13-14.
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39-50.
- Garside, A. L., Bell, M. J., & Magarey, R. C. (2001). Monoculture yield decline—fact not fiction. In *International Society of Sugar Cane Technologists. Proceedings of the XXIV Congress, Brisbane, Australia, 17-21 September 2001. Volume 2* (pp. 16-21). Australian Society of Sugar Cane Technologists.
- Gebre, G. G., & Rik, E. (2016). Sustainability assessment of a banana value chain: The case of Arba Minch, Ethiopia. *Journal of Agribusiness*, 34(2), 1-14.
- Gebre, G. G., Rik, E., & Kijne, A. (2020). Analysis of banana value chain in Ethiopia: Approaches to sustainable value chain development. *Cogent Food & Agriculture*, 6(1), 1742516. DOI: 10.1080/23311932.2020.1742516
- Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. (2010). *Multivariate data analysis*. Uppersaddle River (7th ed.): NJ: Pearson Prentice Hall.
- Hassini, A. T. E. (2015). Performance measurement of sustainable supply chains: a review and research questions”, *International Journal of Productivity and Performance Management*, 64(6), 744 – 783.
- Higgins, A., & Laredo, L. (2006). Improving harvesting and transport planning within a sugar value chain. *Journal of the Operational Research Society*, 57(4), 367-376.
- Higgins, A., Thorburn, P., Archer, A., & Jakku, E. (2007). Opportunities for value chain research in sugar industries. *Agricultural Systems*, 94(3), 611-621.
- Hu, L. T., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods*, 3(4), 424.
- Kalinda, T., & Chisanga, B. (2014). Sugar value chain in Zambia: an assessment of the growth opportunities and challenges. *Asian Journal of Agricultural Sciences*, 6(1), 6-15.
- Kruse, S. A., Flysjö, A., Kasperczyk, N., & Scholz, A. J. (2009). Socioeconomic indicators as a complement to life cycle assessment—an application to salmon production systems. *The International Journal of Life Cycle Assessment*, 14, 8-18.
- Labuschagne, C., Brent, A. C., & Van Erck, R. P. (2005). Assessing the sustainability performances of industries. *Journal of Cleaner Production*, 13(4), 373-385.
- Landis, J. R., & Koch, G. G. (1977). An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics*, 363-374.
- Manda, S., Tallontire, A., & Dougill, A. J. (2020). Outgrower schemes and sugar value-chains in Zambia: Rethinking determinants of rural inclusion and exclusion. *World Development*, 129, 104877.
- Martin, M. A. (2001). The future of the world food system. *Outlook on Agriculture*, 30(1), 11-19.
- Mayer, A. L. (2008). Strengths and weaknesses of common sustainability indices for multidimensional systems. *Environment International*, 34(2), 277-291.
- Meyer, J. H., & Van Antwerpen, R. (2001, September). Soil degradation as a factor in yield decline in the South African sugar industry. In *Proceedings of Int. Soc. Sugar Cane Technol* (Vol. 24, pp. 8-15).
- Moreno, C. A. P., & Salgado, O. (2012). Sustainability indicators along the coffee value chain: A comparative study between Mexican & Colombian retail. *Journal of Management*, 50(8), 65-75.
- Neven, D. (2014). *Developing sustainable food value chains*: FAO.
- Orozco-Romero, A., Arias-Portela, C. Y., & Saucedo, J. A. M. (2020). The use of agent-based models boosted by digital twins in the supply chain: a literature review. In *Intelligent Computing and Optimization: Proceedings of the 2nd International Conference on Intelligent Computing and Optimization 2019 (ICO 2019)* (pp. 642-652). Springer International Publishing.
- Perlata, A. D., & Navarrete, D. M. (2017). Shared Value Creation: Value chain redesign in companies of the sugar sector. *Invention Journal of Research Technology in Engineering and Management*, 1(12), 1-6.
- Pettit, T. J., Croxton, K. L., & Fiksel, J. (2019). The evolution of resilience in supply chain management: a retrospective on ensuring supply chain resilience. *Journal of Business Logistics*, 40(1), 56-65.
- Porter M. (1985). What Is Value Chain. *E-Commerce*, 1-13.
- Rota, A, & Sperandini S. 2010. Value chains, linking producers to the markets. Livestock thematic papers. International Fund for Agricultural Development, Rome. Available at: <http://www.ifad.org/lrkm/factsheet/valuechains.pdf>. Accessed on 12/3/2024
- Srichanthamit, T., & Tippayawong, K. Y. (2018, June). A Framework for Measuring Value Chain Performance in the Sugar Industry. In *International Conference on Mobile and Wireless Technology* (pp. 369-379). Singapore: Springer Singapore.
- Tarekegn, K., Asado, A., Gafaro, T., & Shitaye, Y. (2020). Value chain analysis of banana in Bench Maji and Sheka Zones of Southern Ethiopia. *Cogent Food & Agriculture*, 6(1), 1785103.
- USAID (2012). *A note on indicators of sustainability for value chain project*.
- Warhurst, A. (2002). Sustainability indicators and sustainability performance management. *Mining, Minerals and Sustainable Development [MMSD] project report*, 43, 129.

Yakovleva, N. (2007). Measuring the sustainability of the food supply chain: a case study of the UK. *Journal of Environmental Policy & Planning*, 9(1), 75-100.

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## Appendix

**Table 1.** Results of CFA for Model Comparison (N=473)

| N   | Model               | $\chi^2$ | df  | SRMR | CFI | RMSEA | C.I. 90     |
|-----|---------------------|----------|-----|------|-----|-------|-------------|
| 473 | Single factor model | 1001.40  | 189 | .11  | .79 | .12   | .110 - .130 |
| 473 | Two factor model    | 787.73   | 188 | .09  | .87 | .09   | .081 - .099 |
| 473 | Three factor model  | 567.56   | 186 | .05  | .95 | .06   | .054 - .066 |

**Table 2.** Results of CFA for Triple-bottom-line Sustainability Model (N=473)

| Items  |     |      |               | Factor Loading |
|--|-----|------|---------------|----------------|
| ...production cost   | Q10 | <--- | Economic      | .77            |
| ...labor cost  | Q11 | <--- | Economic      | .79            |
| ...added value   | Q12 | <--- | Economic      | .78            |
| ...production hours  | Q13 | <--- | Economic      | .73            |
| ...logistic costs  | Q15 | <--- | Economic      | .75            |
| ...main income comes from the value chain                  | Q16 | <--- | Economic      | .71            |
| ...tax payment to local government budget                  | Q21 | <--- | Social        | .74            |
| ...transparency of product information                     | Q23 | <--- | Social        | .78            |
| ...clear instruction for workplace safety                  | Q28 | <--- | Social        | .79            |
| ...clear regulation for recalling defective product        | Q35 | <--- | Social        | .85            |
| ...participate in training on planting and relevant skills | Q36 | <--- | Social        | .77            |
| ...participation in charitable activities                  | Q37 | <--- | Social        | .83            |
| ...support for harvesting sugarcane                        | Q42 | <--- | Social        | .75            |
| ...support for improving financial capital accessibility   | Q45 | <--- | Social        | .70            |
| ...gain support for improving arable land management       | Q49 | <--- | Social        | .70            |
| ...join cooperatives gains more benefits                   | Q50 | <--- | Social        | .77            |
| ...support for planting effective sugarcane varieties      | Q58 | <--- | Social        | .73            |
| ...reduce environmental impact by technology and science   | Q38 | <--- | Environmental | .82            |
| ...use renewable energy sources                            | Q39 | <--- | Environmental | .77            |
| ...use recyclable packaging                                | Q40 | <--- | Environmental | .70            |
| ...implement measures to improve the fertility of the soil | Q56 | <--- | Environmental | .83            |

**Table 3.** Factor Correlation Matrix with squared root of AVE on the diagonal

|                  | CR   | AVE  | 1      | 2      | 3      |
|------------------|------|------|--------|--------|--------|
| 1. Economic      | 0.86 | 0.69 | (0.83) |        |        |
| 2. Social        | 0.90 | 0.69 | 0.71   | (0.83) |        |
| 3. Environmental | 0.76 | 0.62 | 0.68   | 0.75   | (0.79) |

CR: Construct reliability

AVE: Average variance extracted

**Table 4.** Mean and SD of sustainability indicators (N = 473)

|                    | Criteria    | Mean        | SD   | Agricultural advisors | Cooperative farmers | Government staff | Dealers | Retailers | Transporters | Material & tool suppliers | Cooperative leaders | Individual farmers | Sugar mill employees |
|--------------------|-------------|-------------|------|-----------------------|---------------------|------------------|---------|-----------|--------------|---------------------------|---------------------|--------------------|----------------------|
| <b>Economic</b>    | Q10         | <b>3.36</b> | 0.84 | 2.90                  | 3.05                | 3.2              | 4.38    | 4.10      | 3.42         | 4.10                      | 3.07                | 3.69               | 3.52                 |
|                    | Q11         | <b>3.44</b> | 0.91 | 2.95                  | 2.98                | 3.40             | 4.33    | 4.10      | 3.46         | 4.00                      | 3.44                | 3.53               | 3.63                 |
|                    | Q12         | <b>3.54</b> | 0.81 | 3.35                  | 3.09                | 3.70             | 4.29    | 4.00      | 3.50         | 4.20                      | 3.66                | 3.58               | 3.58                 |
|                    | Q13         | <b>3.19</b> | 0.88 | 3.10                  | 2.88                | 3.45             | 4.24    | 3.90      | 3.38         | 3.80                      | 2.85                | 3.51               | 3.23                 |
|                    | Q15         | <b>3.55</b> | 0.81 | 3.20                  | 3.26                | 3.40             | 4.23    | 4.10      | 3.65         | 3.90                      | 3.40                | 3.69               | 3.71                 |
|                    | Q16         | <b>3.53</b> | 0.89 | 3.45                  | 3.39                | 2.45             | 3.76    | 3.50      | 3.46         | 3.60                      | 3.42                | 3.76               | 3.83                 |
| <b>Social</b>      | Q21         | <b>3.83</b> | 0.73 | 3.65                  | 3.66                | 4.40             | 4.33    | 3.60      | 3.46         | 4.20                      | 3.72                | 3.78               | 4.00                 |
|                    | Q23         | <b>3.78</b> | 0.74 | 3.85                  | 3.59                | 3.90             | 4.28    | 3.60      | 3.50         | 4.10                      | 3.66                | 3.74               | 3.99                 |
|                    | Q28         | <b>3.92</b> | 0.66 | 4.00                  | 3.76                | 3.75             | 4.33    | 4.30      | 3.88         | 4.10                      | 3.84                | 3.96               | 4.01                 |
|                    | Q35         | <b>3.83</b> | 0.66 | 3.95                  | 3.68                | 3.50             | 4.29    | 3.90      | 3.69         | 4.20                      | 3.75                | 3.90               | 3.93                 |
|                    | Q36         | <b>3.85</b> | 0.67 | 3.85                  | 3.68                | 3.75             | 4.28    | 4.00      | 3.69         | 4.30                      | 3.76                | 3.93               | 3.95                 |
|                    | Q37         | <b>3.85</b> | 0.67 | 3.75                  | 3.71                | 3.80             | 4.33    | 4.00      | 3.77         | 4.30                      | 3.72                | 3.84               | 3.97                 |
|                    | Q42         | <b>3.83</b> | 0.67 | 3.90                  | 3.77                | 3.40             | 4.14    | 3.90      | 3.58         | 3.80                      | 3.87                | 3.84               | 3.90                 |
|                    | Q45         | <b>3.74</b> | 0.71 | 3.60                  | 3.71                | 3.40             | 3.81    | 4.00      | 3.65         | 4.00                      | 3.79                | 3.93               | 3.69                 |
|                    | Q49         | <b>3.80</b> | 0.66 | 3.85                  | 3.87                | 3.30             | 4.33    | 4.20      | 3.42         | 4.00                      | 3.65                | 3.80               | 3.87                 |
|                    | Q50         | <b>3.84</b> | 0.72 | 3.55                  | 3.72                | 3.45             | 4.38    | 4.20      | 3.61         | 3.80                      | 3.72                | 3.94               | 4.02                 |
| Q58                | <b>3.66</b> | 0.69        | 3.60 | 3.78                  | 3.90                | 4.57             | 4.50    | 3.54      | 4.00         | 3.68                      | 3.93                | 4.02               |                      |
| <b>Environment</b> | Q38         | <b>3.77</b> | 0.66 | 3.75                  | 3.61                | 3.55             | 4.29    | 4.10      | 3.73         | 4.30                      | 3.73                | 3.84               | 3.77                 |
|                    | Q39         | <b>3.74</b> | 0.69 | 3.85                  | 3.66                | 3.45             | 4.43    | 3.80      | 3.50         | 4.10                      | 3.62                | 3.78               | 3.83                 |
|                    | Q40         | <b>3.66</b> | 0.71 | 3.80                  | 3.58                | 3.35             | 4.43    | 3.80      | 3.46         | 3.80                      | 3.64                | 3.71               | 3.62                 |
|                    | Q56         | <b>3.91</b> | 0.60 | 3.90                  | 3.82                | 3.60             | 4.43    | 4.30      | 3.65         | 3.80                      | 3.88                | 4.04               | 3.95                 |