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Sustainability Assessment and Agricultural Supply Chains Evidence-Based Multidimensional Analyses as Tools for Strategic Decision-Making—The Case of the Pineapple Supply Chain in Benin

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Citation: Desclee, D.; Sohinto, D.; Padonou, F. Sustainability Assessment and Agricultural Supply Chains Evidence-Based Multidimensional Analyses as Tools for Strategic Decision-Making—The Case of the Pineapple Supply Chain in Benin. *Sustainability* **2021**, *13*, 2060. <https://doi.org/10.3390/su13042060>

Academic Editors: Robert Home and Mark A. Bonn

Received: 19 December 2020

Accepted: 11 February 2021

Published: 14 February 2021

Abstract: Contributing to Sustainable Development Goals and Agenda 2030 is a shared objective of all institutions and people. The challenges differ according to the characteristics of every context. In developing countries, strongly dependent on the agricultural sector, agricultural supply chains are recognized as crucial for economic growth and enablers for livelihood improvement. Moreover, sustainable development issues are correlated and can meet in agricultural supply chains. For several decades, parallel to decision-makers, the research community has elaborated sustainability assessment tools. Such tools evolved to fit with actuality, but it is challenging to find decision-making support tools for sustainable development adequate in agricultural supply chains and developing countries contexts. There is a necessity to define evidence-based tools and exhaustive analytical frameworks according to sustainability multidimensionality and strategical tradeoffs necessity. The VCA4D method aims to go beyond the limits of previous methods. It proposes a combination of multidisciplinary analytical tools applied empirically to analyze agricultural supply chains in their context. It provides evidence-based analytical results allowing to identify enablers for strategic sustainable and inclusive interventions. However, to even better meet contextual exhaustiveness's expectations and indicators' robustness to lead to relevant interventions, we should insist on a stricter framing of contextual data collection processes.

Keywords: sustainable development; assessment; analytical framework evidence-based diagnosis; pineapple; Benin; agricultural supply chain; value-added; enablers; economic impacts; social impacts; environmental impacts; sustainability; inclusiveness

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1. Introduction

Today, the 2030 Agenda and the Sustainable Development Goals (SDGs) adopted by institutional bodies worldwide require everyone to demonstrate that they apply sustainable development principles in their actions. It contains a set of measures aiming to balance economic progress and protection of the environment, whilst at the same time remain aware of the need to address the many national disparities known [1]. However, the three pillars of sustainable development, economy, society, and environment, and their links are commonly adopted. Equally, the need to take them into account in a multidimensional way is validated. The Agenda 2030 goes beyond referring to sustainable development as development grounded in the “5 Ps”: people, planet, prosperity, as well as peace and partnerships. This enlargement of the sustainable development concept and interventions provides new guidance for due diligence for any intervention to address development and societal challenges.

This growing concern affects activities and decisions in all countries, whether developed, emerging, or developing. The transitions to sustainability assessment and initiatives have spread widely, but mainly in industrialized countries. Nevertheless, sustainability questions are particularly relevant in the developing world. Developing countries are generally characterized by a mixture of well- and ill-functioning institutions, a context of market imperfection, social exclusive communities, and patriarchal households. In such economies, many activities generating growth and income are organized through agricultural supply chains. Moreover, in rural contexts, gathering empirical data needs researchers and research methods to deal with the specificities of socioeconomic interactions [2]. However, sustainability plays a fundamental role in growth and prosperity [3].

In many countries, agricultural supply chains are essential for agricultural development due to their trans-sectorial capacity to create economic value and employment inclusively and sustainably. They represent an operational framework for engaging with farmers and businesses. Otherwise, developing countries depend critically on their agricultural sector for job creation, household incomes and livelihood, and economic growth. Value chains are the set of sequenced value-creation activities that convert raw materials to final products and the primary mediator between agroecological systems, households, production activities and markets. More specifically, agricultural value chains are essential in developing countries for their impact on employment and income growth generation, market opportunities for consumers and producers and sustainability potential through existing operations conducted in the supply chain [4].

Despite the many initiatives in developing countries to start a transition towards sustainable development of their economy mainly dependent on the agricultural sector, sustainability and its assessment in agricultural supply chains are subject to many debates. Indeed, even if the sustainability of these complex “systems” is analyzed from a multidimensional perspective, they remain so dynamic in time and space that it is almost impossible to establish if they are “sustainable”. Often, in their analysis, one or two of the dimensions of sustainability are favored. On the other hand, multidisciplinary analyses make it possible to give a more comprehensive image of the system and apply more relevant sustainability performance approaches. After all, the relevance of this type of approach applied to agricultural supply chains is only reinforced if they result from a participatory process and collaboration between all the stakeholders and actors involved in the system and the will to make it tend towards sustainability [5].

It is recognized that there is an urgent need for sustainability targets that must be considered as a decision-making strategy. The SDGs and Agenda 2030 can also facilitate the implementation of strategies for sustainable development, both in public and private sectors [1]. Since the onset of the desire to initiate a transition to development, the international community of researchers and organizations has sought guides and analytical frameworks to support decision support in supply chains. However, until today, in a very dynamic research environment, the proposals responded mainly to socioeconomic development expectations not aboard sustainable development’s environmental dimension [6,7].

With this in mind, the European Commission (EC) developed a multidisciplinary analysis framework to be applied to growth-generating supply chains in emerging and developing countries. This framework, called the Value Chain Analysis for Development (VCA4D), provides evidence-based information and knowledge pragmatically and operationally to inform policymakers’ sustainable development strategies and stakeholders involved.

To support agricultural supply chains development, since 2017, Benin has embarked on a reform of the agricultural sector [8,9]. The government and its partners have adopted a strategy of developing the agricultural sector as the main lever of economic development, wealth creation and jobs. In this context, particular emphasis has been placed on the development of high added-value sectors, including pineapple [10–14].

The sustainability and inclusiveness diagnostic study of the pineapple supply chain in Benin according to the VCA4D methodology [15] aims to provide factual elements,

supported by various indicators, to understand at what levels of the supply chain inputs can lead to value-added and growth generation, as well as sustainability improvement of the supply chain itself.

2. Literature Review

2.1. Sustainable Development Goals and Agenda

The concept of “sustainability” is not new. All agree that the Brundtland Commission final report initiated by the United Nations laid a definition of the concept of “sustainable development” as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (1987). Sustainability is a holistic approach integrating economic, social and environmental dimensions to be considered together. In the commonly adopted world’s development agenda, economic sustainability refers to practices that support long-term economic growth without negatively impacting communities and the environment. Social sustainability occurs when formal and informal processes and systems involving human relationships actively support people’s capacity to create viable communities. Finally, environmental sustainability consists of limiting natural resource use and protecting ecosystems for supporting current and future well-being.

The community approval of the concept of sustainability initiated the adoption by the world community of many agreements to combine efforts to achieve sustainable development on earth: the Rio Summit and the Agenda 21 in 1992, the Kyoto Protocol in 1997, the Millennium Development Goals in 2000, Rio+20 in 2012, Sustainable Development Goals and Agenda 2030 in 2015. The Agenda 2030 “5 Ps” provide new guidance for due diligence for any intervention to address development and societal challenges. It means that any development intervention to be sustainable has to consider the social, economic and ecological consequences it generates and lead to conscious choices in terms of the trade-offs and spin-offs it creates. As discussed by the United Nations [16]: *“Decision-makers involved need to consider to what extent it is developed, owned and carried forward in partnerships, including with the people who will live with the consequences of the intervention. One also needs to look at the dimension of peace and governance, analysing the wider societal context in terms of drivers of tension and conflict and effects on social cohesion and inclusion, anticipating the consequences it could generate to exacerbate or appease them. The sustainable development approach provides a new tool for due diligence to identify the most appropriate development intervention in a given context. It obliges us to ask new questions and seek answers from new sources. It needs to trigger new dialogues, bringing actors and constituencies together that would not typically talk to each other and work together.”*

This whole process of SDG development gives them an important role in current sustainability discussions and policies. They consist of a roadmap followed by the international community to guide decision-making and strategies. The SDGs’ complex system of correlations, relationships, synergies, and trade-offs represents a challenge for planners and decision-makers. Due to its conceptual complexity, it is challenging to translate some of the SDGs into measurable indicators. Nevertheless, the data needed for indicators measurement are not always available. Therefore, the adoption of systemic and integrated approaches is recommended at both the stakeholders’ micro-level and at the more strategic macro-level to contribute to the SDGs [17].

2.2. Sustainability Assessment

The world Sustainable Development objectives have led the scientific community to study sustainability and address how to assess this notion with indicators. The premise of sustainability assessment was in 1996, when an international group of experts developed the “Bellagio Principles—Guidelines for Practical Assessment of Progress Toward Sustainable Development”. Later, along the same line, Bellagio STAMP’s first principles dealing with the starting point of sustainability assessment were developed [18]. These principles can be summarized by: (1) adopting a guiding vision, (2) having essential considerations, (3) using an adequate scope, (4) defining a relevant framework and indicators, (5) apply-

ing transparency, (6) implementing effective communication, (7) and broad participation, and (8) supporting continuity and capacity [19]. They allow the establishment of a guiding vision.

In 2004, Pope et al. developed several models proposing different normative orientations about how sustainability should be represented and what sustainability assessment should achieve. Unfortunately, none of their models gave concrete indications on the dimensions of decision-making context and methodology. It motivated the researchers to develop other models and frameworks.

In early 2010, Sala et al. proposed a more accurate framework using three dimensions for completing a sustainability assessment: an approach to sustainability, the need for decision-making context, and the impact of methodological choices. This framework draws upon the Bellagio STAMP principles revised by Pintér et al. Sala et al.'s approach brings together sustainability principles and values that are both science- and policy-based and allow for measurable sustainable targets assessment [20].

At the same time, Hugé et al. (2013) offered a framework for categorizing sustainability assessment based on sustainability-related discourse. The concept consists in setting:

“a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced and transformed in a particular set of practices and through which meaning is given to physical and social realities” [21].

Those sustainable assessment working groups laid the first way of setting sustainable assessment vision by proposing assessment frameworks for decision-making support.

In parallel, from 2006, another movement of thoughts addressed sustainability assessment to seek to answer typical decision questions. In this sense, Morrison-Saunders and Thérivel analyzed and strengthened the link between sustainability decision questions and the level of decision-making. They thought that taking into account the strategic decision-making contexts increased the decision-making for sustainability integration potential. Some decision questions may directly reflect a particular sustainability discourse [22].

2.3. Agricultural Supply Chains Sustainability Assessment and Management

According to Kaplinsky and Morris, “Value Chains describe the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use.” [23]. A supply chain concept includes several processes from production to processing, trading, distribution, and consumption. There is an increasing awareness of the economic, social and environmental impacts of and on agricultural food production and consumption. Moreover, in developing countries facing food and nutrition and sustainability issues, agribusiness and agricultural supply chains play a fundamental role in the economy. The new world focuses on sustainable development. Agricultural supply chains are the linked operations from the primary agricultural production to the end-use of the product and/or its processed products.

Outside, somewhat before, questions of sustainability assessment, agricultural supply chains were already analyzed. Several systemic and strategic approaches have been studied for supply chain analysis. The French Systematic Method initiated in the 1960s and based on the concept of “filière” is a descriptive approach focused on physical flows and the input–output links and value-added it can generate. This approach is criticized because it is considered static, not considering dynamic characteristics of growth and fall of products, knowledge, and the number of actors. Furthermore, the approach is considered too descriptive, neglecting the strategic approach to value chain analysis. Another suitable method applied to supply chains is the “comparative advantage”, one developed by Porter (1985). This method recommends analyzing the activities, processes, performances and skills carried out in the supply chain and linking them to a strategy. In practice, the method makes it possible to highlight the supply chain development opportunities and at what level it would be most opportune to implement them according to the context

and strategic objectives [23]. Sustainable outcomes of agricultural supply chains depend on the balanced achievement of economic growth, social and well-being development, and environmental protection. The agriculture sector was identified as predominant for achieving sustainable development and growth if more efficient management practices considered social and environmental sustainability aspects. It implies that to be relevant, the sustainability analysis of agricultural supply chains must be data-driven and needs a practical framework [24].

To complement analytical work done on agricultural supply chains and sustainable development, it is relevant to briefly review what is done about Sustainable Supply Chain Management (SSCM), linking sustainability assessment and supply chain concepts. Recent literature reviews on sustainable supply chain management demonstrate a rising concern about applying sustainable development issues in emerging and developing countries. In those countries, economies are dependent on the agricultural sector and people's livelihoods on agricultural supply chains. Field studies and methodologies indicate that sustainability improvements can only be achieved if a triple-bottom-line approach (based on the three sustainability dimensions) is integrated along the supply chain. It is the only way to minimize losses and failures in operations and optimize economic and well-being performances. Researchers use different descriptions of Sustainable Supply Chain Management (SSCM). The purpose of all definitions is to highlight that a supply chain can be a crucial component for achieving sustainable development, while economic, social and environmental criteria are satisfied. Finally, as proposed by Sanchez-Flores et al., supply chain management can be understood as the preservation of balance that may exist between social responsibility, care for the environment and economic feasibility throughout the supply chain functions [3].

Numerous SDGs have strong positive correlations among them. While concerning trade-offs, SDG12 (Responsible consumption and production) is the one that shows more strong and moderate negative correlations with other SDGs; Sustainable development Goals Relationships and correlations [17]. SDG 12 is undoubtedly one of the SDGs most related to applying sustainability processes in agricultural supply chains that connect several sectors of the economy. Today, in this logic, we expect that any intervention along an agricultural supply chain meets the ISO 22000 Standard [25]. ISO 22000 sets out the requirements for a food safety management system and can be certified to it. It maps out what an organization needs to do to demonstrate its ability to control food safety hazards to ensure that food is safe. Any organization can use this standard regardless of its size or position in the food chain (<https://www.iso.org/iso-22000-food-safety-management.html>). Indeed, in the overall context of globalization, a broader consideration of the natural environment's needs, and sustainable development, people become responsible for developing supply chain management strategies and assessing supply chains for meeting the ability to adapt to changes and predict future market trends. Implementing the requirements of the ISO 22000 standard in food supply chains can positively affect the implementation of critical processes contributing to sustainability and responsible production and consumption by reducing food waste at each stage of the supply chain [25].

2.4. Guides and Frameworks for Supply Chains Development and Sustainability Strategies

In 2011, the World Agroforestry Center proposed a review of the guidelines and manuals for value chain analysis for agricultural and forest products [6]. This initial review was completed in 2015 by proposing a comparison between the existing guides on value chain development [7].

In the first paper, the authors note that many development practitioners have made extensive use of the supply chain concept to design market-driven rural development projects and strategies. Consequently, at the beginning of the 2000s, many manuals and guides were produced at the premise of sustainable development concepts. Unfortunately, despite this proliferation, the tools were developed with different objectives, which caused confusion and ultimately led to a lack of real guidance and tools used in different contexts.

They conclude that: the methodologies used at the different stages of supply chain analysis are often quite different, the context is poorly taken into consideration, the results do not allow comparisons between analyses, that analyses should be further combined with analytical methods to go beyond case-specific conclusions and ensure comparability across sites and applications [6].

The most recent paper was published in a more prominent development strategy guided by the development goals and aimed at stimulating economic growth and increasing the agricultural sector's competitiveness through interventions and support in supply chains. The authors reviewed 11 different guides for value chain analysis and development. Their findings are that all guides reflect development organizations' interest in achieving greater sustainability for their strategic interventions. They observed that sustainability could only be achieved if a strong focus is given on the analysis of flows and interactions between actors, their well-being needs, and their willingness to adopt an environmental and social responsibility in their actions. Analyzing supply chains in developing countries requires the use of additional and appropriate concepts and tools. Approaches have to give more guidance for dealing with diverse contexts and how to deal with contextual issues related to supply chain functioning and structure. Finally, their conclusion is that a clear emphasis must be given on experts that implement the methodologies and tools according to the development and sustainability goals to be achieved [7].

The literature review of the main concepts confirms that sustainable development is a broad and integrative concept. It means that sustainability diagnosis and progress assessments must be integrative too, contextual and match with decision-making objectives and framework. It is the aim of the VCA4D framework, whose final purpose is to apply sustainable supply chain management recommendations and decision-making support on agricultural short supply chains in developing countries.

3. Materials and Methods

Initiated in 2015, the VCA4D framework was rooted in the findings of a review of the approaches and frameworks for analyzing value chains that generate economic growth. The European Commission's strategic interest was to strengthen its initiatives in the growing sectors of emerging and developing countries while ensuring that the transition to sustainable development objectives was respected.

While many questions arise in terms of the sustainability of agricultural systems and supply chains, the approach to sustainability is multidisciplinary. Understanding the concept of sustainability implies carrying out quantitative and qualitative analyses in each of the three sustainability pillars: economic, social, and environmental. Systematic, contextual, and strategic approaches have to be adopted to identify the barriers and potential leverage effects of an agricultural supply chain. According to the strategic objectives of the supply chain analysis of sustainability, it is relevant to conduct multidimensional studies in parallel and draw common conclusions to put in place actions aimed at tending towards sustainability. Moreover, the agricultural value chain analysis frameworks developed since the beginning of the 2000s showed that socioeconomic challenges were often addressed, but not about the inclusivity and environmental factors specific to the notion and sustainability goals. It was also necessary to go beyond the problems of the context's impact on the analyses [6]. Truly little correlation between the new SDGs was considered as this was not relevant before 2015 [17].

The VCA4D framework's ambition is to follow the new guidelines introduced in the Agenda 2030 and the 5Ps to help decision-makers with sustainable interventions in the supply chains of emerging and/or developing countries. In this section, the VCA4D method applied on supply chains is presented. Its application to Benin's pineapple supply chain's practical case is introduced as a context for the materials and the empirical data.

3.1. The Beninese Pineapple Short Supply Chain Context and Decision-Makers Strategies

The Beninese economy relies heavily on informal export and transit trade with Nigeria (which accounts for around 20% of GDP) and its primary sector. Growth accelerated from 5.6% in 2017 to 6% in 2018 (growth rate of GDP per capita of 3.1%), thanks to port activity dynamism and a growing agricultural sector supported by record cotton production and emerging sub-sectors diversification [26].

Since 2017, Benin has embarked on a reform of the agricultural sector [12–14]. The reform is supported by the Strategic Plan for the Development of the Agricultural Sector (PSDSA) and the National Strategy for the Promotion of Agricultural Sectors, integrating an agricultural cluster approach from 2017 to 2021 [13]. To this end, the Government of Benin has made the option of investing in large-scale agriculture, following a strategy combining the territory approach and the sector approach to constitute relatively homogeneous zones or “Agricultural Development Poles (PDA)” with the purpose of better valuing local potential. In this context, particular emphasis has been placed on the development of high added-value sectors, including pineapple. Given the importance of agricultural supply chains (cotton, cashew and pineapple) for the national economy, the Government of Benin, objectively, has planned in its Action Program, a structural transformation of the economy to make the agricultural sector the main lever of economic development, wealth creation and jobs [15–19].

In Benin, pineapple is one of the main export crops after cotton and cashew nuts. Pineapple comprises one of the primary agricultural productions in the Atlantic department which have a concentration of 98% of national production [27]. New emerging areas are being identified in the country to extend the production.

Two varieties of pineapple are cultivated, mainly the Sugar Loaf variety (75%) and the Smooth Cayenne (25%). The first and mainly produced variety is a regional specialty highly appreciated by consumers locally and internationally [28]. Unfortunately, this variety is fragile and can be kept for only a few days and does not support transport well. Consequently, there is a real interest in increasing Sugar Loaf production and processing but in a short supply chain to better serve local and regional consumers of fresh fruit and juice (which allows for longer storage) [29–32].

Juice processing and consumption imply the involvement of the secondary sector in the supply chain.

In terms of exports, the Sugar Loaf most produced pineapple variety in Benin cannot compete with the varieties produced by the world’s leading exporters, Costa Rica and its neighbors. Benin is interested in developing the different pineapple supply chain levels but only targeting a local and regional market.

Data show that the pineapple supply chain is highly dependent on trade in fresh fruit and juice with Nigeria, which is the largest consumer of these products. Nigeria sees its population growth increase every year and the demand for pineapple-related products continues to grow. Nigeria is a potential niche market for Benin’s fresh pineapple and juice production. Nevertheless, the flip side is that the Beninese economy depends extremely on its neighbor’s decisions and policies. This was the case, for example, when Nigeria closed its border to imports of processed products to promote its secondary sector [33].

Knowing this context and the strategic objectives of decision-makers, the European Commission wished to support Benin’s partners by implementing a diagnostic analysis of sustainability and inclusiveness, applying the VCA4D methodology empirically on the pineapple supply chain in Benin.

3.2. The Value Chain Analysis for Development (VCA4D) Framework

In light of the literature review on sustainability assessment, as well as the reviews of guides and frameworks designed for supporting strategic decision-making [6,7], it is considered that the VCA4D framework aims at conceptualizing sustainable development as a decision-making strategy. In this sense, sustainable development becomes an “action-guiding” power in a decision-making strategy [16].

The VCA4D framework aims at the application of an analysis method on a supply chain to highlight the impacts, the drivers of change, the leverage effects; and identify which levels, which actors, which investments and supports could be beneficial to supply chain and creation of advantages by seeking to reduce constraints.

The VCA4D methodology [16] consists of proposing an operational representation of the supply chain system as a reference situation and elaborating a multidisciplinary diagnosis to measure growth and sustainability indicators facilitating decision and concrete interventions support.

The primary characteristic of the application of the sustainability analysis methodology as a decision-making tool for the sustainable development of supply chains in developing countries involves responding to three crucial challenges identified by Waas and al., namely: the interpretation of the concept of sustainability as organizational principles in a specific context, the establishment of a structured process around operational data and information that accounts for the multi-dimension of the sustainability assessment, and the influence that the data, results and interpretations can have on the strategies put in place to move towards sustainable development [18].

When applying the VCA4D methodology, the supply chain is analyzed through four main axes, including the three sustainable development pillars: a functional analysis, an economic analysis, a social analysis and an environmental analysis of the supply chain. A multidisciplinary team of experts conducts the three-dimensional analyses separately but with the same “picture” of the supply chain and context (functional analysis). It guides decision-making by assessing appropriate indicators, setting up baselines and/or informing on the potential intervention impacts on stakeholders. VCA4D Studies are planned to clarify the expectations of the decision-makers and the research team to understand the context, the motivations, and the needs that led the request for the analysis [16]. The strategy underlying the interventions in the supply chain is better known, which enables them to better account for their inclusiveness and sustainability. The VCA4D approach focuses on contextual characteristics with the functional analysis as a common starting point and whose goal is, for the multidisciplinary team of experts conducting the supply chain analysis, to understand and describe the context in which the supply chain operates.

The functional analysis is the common starting point. It presents a detailed “snapshot” of the organization and functioning of the entire system and lays the foundations for economic, social and environmental analyses. These are then carried out to answer general questions: (1) What is the contribution of the supply chain to economic growth? (2) Is economic growth inclusive? (3) Is the supply chain socially sustainable? (4) Is the supply chain environmentally sustainable?

The functional analysis follows the French Systematic Method concepts [23], but without going beyond its limits and shortcomings. It represents the supply chain system by identifying the series of steps from the initial (agricultural) production to the final consumption (or export) and the actors involved at each stage. The activities/operations of these agents are geographically localised. Products, financial and information flows between actors and areas are identified and quantified. Understanding how the whole system works lays the groundwork for undertaking the economic, social and environmental analyses. The research team identifies a typology of the main actors operating in the supply chain and physical flows they exchange according to data collected and national experts’ validation. They are defined precisely in the functional analysis to ensure that economic, social, and environmental analyses are completed within the same contextual framework. It results in a description of the main functions and operations, a general mapping of activities and actors, identifying the relevant key features of the context, identifying (known) constraints, and quantitative guidance for specific analyses within each of the sustainability pillars. More qualitative elements are discussed, such as governance in the supply chain, as well as an analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT). The objective is to obtain a presentation of the supply chain’s operation as exhaustive as possible while knowing that it is an image produced at a given moment. No dynamic explicitly linked to

the evolution of the supply chain and sustainable development is represented. This supply chain representation can be considered the baseline situation, without interventions to tend towards sustainable development. In most developing countries, data such as those collected empirically for VCA4D analyses are not recent or reliable. It gives all importance to collecting data and qualitative and quantitative, and multidimensional information carried out by multidisciplinary experts in the field. The functional analysis can use different tools, but finally, it has to give a detailed description of the main functions and operations, a general mapping of activities and actors, a factual description of technical processes and channels, the identification of the relevant key features of the context, the identification of the main constraints to development, a governance analysis, deepening of key elements for all three development pillars and analyses of the supply chain.

To achieve a relevant and exhaustive functional representation of the supply chain, the team must review the existing secondary data. Suppose the data are missing or the supply chain representation is difficult to achieve because it can only be based on secondary data. In that case, the expert team implements a primary data collection process. As a result, surveys and focus groups are carried out with key players and stakeholders operating in the supply chain. In this way, the empirical data necessary for using the three dimensions' analysis tools: economic, social, and environmental, are gathered.

The economic analysis in VCA4D is based on the economic growth concept. It means that, theoretically, the analysis is focusing on revenue and added-value measurements. In this perspective, the data necessary for the measurements come from primary and/or secondary data. Secondary data are often supplemented by primary data collected in the field through surveys. It helps to make empirical information more robust and more recent. The economic analysis consists in four steps: (1) undertaking the "financial analysis" of main actors involved in the supply chain identified, (2) assessing the overall effects of the supply chain in the national economy, (3) analysing the sustainability and viability of the supply chain within the international economy, and (4) assessing the growth generated in the supply chain inclusiveness [16]. The financial analysis focuses on evaluating all costs and benefits of the main actors involved in the supply chain at market prices. The initial and main quantification tool used is the stakeholders' operating account (producers, processors, traders) identified in the functional analysis. They are reconstructed from data on the monetary values exchanged. Individual revenues, costs and benefits are estimated, and the added value generated by the activity of actors in the supply chain is estimated. Then, by applying the principles of consolidation well known in economics, the income and added value generated in the supply chain are estimated by groups of actors, type of operations, channels. These measures make it possible to establish the value of production and the added value generated by the supply chain itself. The added value and its components (wages, intermediate consumptions, domestic consumption, imports) are measured to calculate key economic indicators such as the value-added shares of the supply chain on GDP and agriculture sector GDP, the rate of integration of the supply chain into the national economy and the balance of trade of the supply chain. The third step consists of evaluating the effects of the supply chain on the international economy or the supply chain's international competitiveness. The Nominal Protection Coefficient (NPC) and Domestic Resource Cost Ratio (DRC) indicators are measured [34]. The quantification of financial and economic indicators allows comparisons with other data or benchmarks.

The analysis of social sustainability and inclusiveness aims at assessing evidence-based established and potential impacts related to the activities of the supply chain [16]. It allows identifying relevant elements and specificities of the pineapple supply chain in Benin in six areas: working conditions, land and water, gender, food and nutrition, social capital and living conditions. The social analysis is a reflective process conducted based on key information and assessment. The purpose is to identify operations or contextual issues that improve or negatively affect social groups or stakeholders' situation. A tool has been developed and consists of a Social Profile spreadsheet to complete and

obtain a radar diagram representation of the supply chain's social profile according to the 6 social thematic.

The method selected to evaluate the environmental sustainability of the supply chain is the Life Cycle Assessment (LCA). Over the last few decades, LCA has been normalised, promoted and used by various public and private actors. The upper-level reference for this methodology is given by two ISO norms (ISO 14040:2006 and 14044:2006) [35,36]. The use of LCA in supply chain sustainability analysis is explained by the fact that this tool used the same data as those collected for the economic analysis. An LCA is based on the quantification and analysis of flows regarding resource depletion, ecosystem quality and human health. An inventory of the resources and inputs used and emitted in the supply chain operations is done. After processing with LCA tools, impacts on the three environmental "areas of protection" are estimated. It helps decision-making by pointing to the significant environmental impacts of the supply chain, operations, or channels. It gives possibilities for comparisons of environmental sustainability of channels or production systems (for example, conventional versus organic).

The economic, social, and environmental analyses proposed are very data-demanding, because they aim to provide evidence-based information. Due to the difficulty of gathering the data necessary to carry out the quantitative analyses included in the VCA4D approach in developing countries, the multidisciplinary researchers' team starts by collecting information and data in the field. If reliable and recent data exist to measure economic, social and environmental indicators, they are used as secondary data. However, it supposes the experts to find a large gap in the data. In that case, they undertake a multidimensional survey questionnaire to be submitted to the identified actors active in the supply chain. It allows them to use relevant data to better understand the supply chain's context and representation.

The analysis of the supply chain with the VCA4D methodology allows the identification of relevant impact pathways, and highlights at which level of the supply chain, and for which actors, investments and support could generate more benefits and positive externalities and minimize constraints and bottlenecks. It enables the tracking of how development actions contribute to Sustainable Development Goals [16,17]. It is not theoretically an assessment, but a combination of analysis methods allowing to establish a diagnosis and target the enablers to be highlighted to evolve towards a more sustainable supply chain in a given context. Nevertheless, this method has the merit of allowing an in-depth multidisciplinary analysis to provide information and guidance to decision-makers according to a context and the 5 Ps that qualify the interventions' sustainability.

4. Results and Interpretation

The results of the VCA4D methodology's application to the pineapple supply chain in Benin are presented. The emphasis is on socioeconomic results. However, the study aims to focus on the three sustainable development pillars to identify bottlenecks and potential leverage effects, demonstrating that compromises must be made to tend towards sustainability and inclusiveness in the supply chain.

To feed the discussions in the following section, the results and interpretations of the study carried out by a group of experts (including the authors) on the pineapple supply chain in Benin presented below are supplemented by succinct results and interpretations obtained by another group of experts who applied the same VCA4D analysis framework to the pineapple supply chain in Togo.

VCA4D analyses' results are presented following the structure requested by the VCA4D Methodology for research reports. All reports and summaries of the results have the same structure. Firstly, the functional and contextual elements are presented, then the economic analysis, followed by the social analysis and the environmental analysis. It is concluded with findings and recommendations for decision-making support and trade-offs for achieving better growth sustainability and inclusiveness.

4.1. The VCA4D Method Applied to the Pineapple Supply Chain in Benin

Benin aspires to sustained, inclusive and sustainable economic growth. The policies are in continuous reflection on the possible evolutions of the activities generating value added in agricultural and industrial processing areas to serve this objective. Aware of the need to encourage the secondary and tertiary sectors in the same way as the primary sector to generate economic growth, the Beninese government sets up a structural transformation in order to exploit the possibilities offered by other sectors and technological innovations.

The country is unfortunately exposed to exogenous shocks such as climatic hazards that impact agricultural yields, fluctuations in the terms of trade with Benin's main export market, its neighbor Nigeria (oil price, opening of markets for processed products, protectionism, etc.). The business environment in Benin is relatively unattractive for national and international investors. Access to credit remains a difficult barrier to overcome for people wishing to develop any activity.

The sustainability and inclusiveness study of the pineapple supply chain in Benin aims at identifying trade-offs that must be made to ensure that the added value generated is growing and sustainable, as well as extending the positive impact it generates on the community evolving in this supply chain.

4.1.1. The Functional Analysis

The pineapple supply chain in Benin is organized through three main functions: primary production (average of 345,000 tons/year in 2017) of Sugar Loaf and Smooth Cayenne varieties, juice processing and fresh fruits and juice retail or wholesales (local, regional and exports) [37,38].

On the basis of key actor surveys (39 producers, 10 traders, 6 processors) and interviews (3 producers, 1 retailer and 1 wholesaler, 1 artisanal processor, 1 semi-industrial processor, 1 industrial bio and 1 industrial conventional) and focus groups (Producers Association, Retailers Association, Exporters), data collected on the field and secondary data [37–48], different types of producers have been identified: isolated or supervised (Linked to a cooperative, an association or formally with processors/traders.) producers producing pineapple in a conventional way (they use the same production process but obtain different yields due to the volumes produced and losses at different levels), supervised producers producing organic (bio) pineapple and supervised producers with conventional agricultural practices with high-quality standards targeting end consumption. In terms of processors, there are many artisanal, a few semi-industrial and one industrial juice processors. Finally, more than 50% of the pineapple (fresh fruits and juice) production is consumed in Nigeria, while less than 2% of the initial production is exported outside the sub-region (West Africa, mainly Nigeria, Mali, Burkina Faso, etc.) [39–48].

In the supply chain (Figure 1), six (6) channels were identified. Four (4) channels subdivide the main channel of pineapple produced in a conventional way (by isolated producers and supervised producers). Pineapples produced are either sold as fresh fruit or transformed into juice in artisanal, semi-industrial and industrial processing units. No distinction is made in the production process to make a pineapple for sale as fresh fruit or for processing into juice. This channel represents 98% of the total value of pineapple production in Benin. However, it is subdivided into: (1) the conventional pineapple channel of fresh fruits marketed in the sub-region and Nigeria, (2) the conventional pineapple channel of fresh fruits traded locally, (3) the conventional pineapple channel processed into juice and traded (unofficially exported) in the sub-region, (4) the conventional pineapple channel processed into juice and traded locally.

To complete the picture, two additional but very embryonic channels are (re-)emerging, (5) the organic pineapple channel (and whose specific processing and sales processes only apply to the organic primary product). This channel is not easy to understand in detail because it is dominated by a single player in the processing and sale of processed products (mainly in Europe). Finally, (6) the pineapple channel produced in a conventional manner but according to quality criteria specific to export to EU and the Middle East. This export

channel is being reborn. The actors who are active in this channel do not easily share information about their activity.

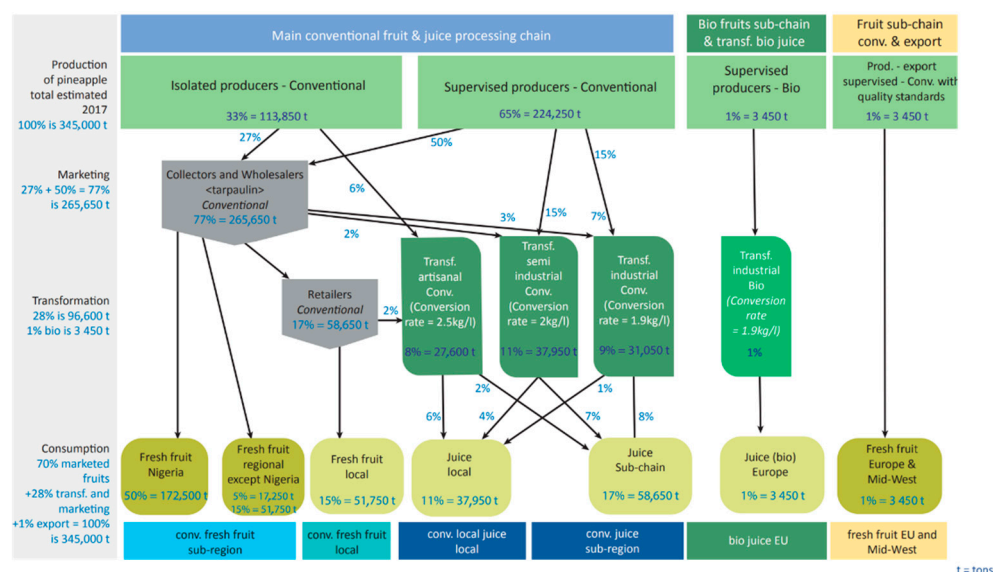


Figure 1. The Pineapple Supply Chain in Benin (t = tons).

4.1.2. The Economic Analysis

As presented in the methodology used, a financial analysis of the actors identified in the functional analysis led to representing the production-operating accounts, using primary data from surveys and focus groups and secondary data from previous Beninese pineapple supply chain analyses conducted by local researchers and for donors [45–48]. Then, the accounts consolidation by the “actors” group allows the measurement of net profits, value added and shares, generated by each main group of actors in the supply chain (Table 1).

Table 1. Consolidated financial results per group of actors or operation identified.

Operations/Actors	Net Profit in Francs CFA	Value Added in Francs CFA	Total Net Profits Shares	Total Value-Added Shares
Supervised producers (Conv)	3,575,293,997	5,493,916,750	35%	31%
Isolated producers (Conv)	2,380,004,363	3,062,059,629	23%	17%
Collectors/wholesalers	534,713,094	1,257,734,824	5%	7%
Semi-industr. Processors	837,577,711	1,753,936,846	8%	10%
Retailers	63,380,186	63,380,186	1%	0%
Supervised producers (Bio)	157,375,430	238,924,000	2%	1%
Producers - exporters	101,493,490	215,858,594	1%	1%
Exporters	671,025,000	3,174,000,000	7%	18%
Artisanal processors	351,588,739	885,897,126	3%	5%
Industrial processor (Conv)	257,555,457	302,120,191	3%	2%
Industrial processor (Bio)	1,221,906,543	1,351,011,535	12%	8%
Overall Supply Chain	10,151,914,009	17,798,839,681	100%	100%

The supply chain’s impact on the national economy is measured through the direct value added generated by operations and actors in the supply chain. In the case of the pineapple study in Benin, the supply chain directly generates 17.8 billion Francs CFA (FCFA). The breakdown of the value added generated by the six (6) channels provides more information. Channels linked to conventional production, transformation into juice and local consumption and/or in the sub-region are those which generate a large part

of the value added, as do the actors who produce and process conventionally cultivated pineapples (Figures 2 and 3).

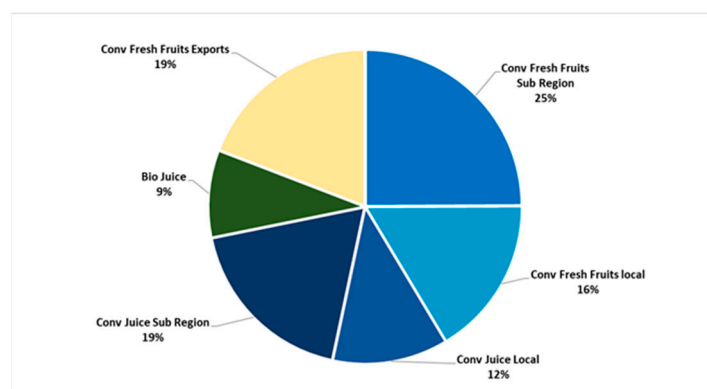


Figure 2. Value-added shares per supply chain channels and actors.

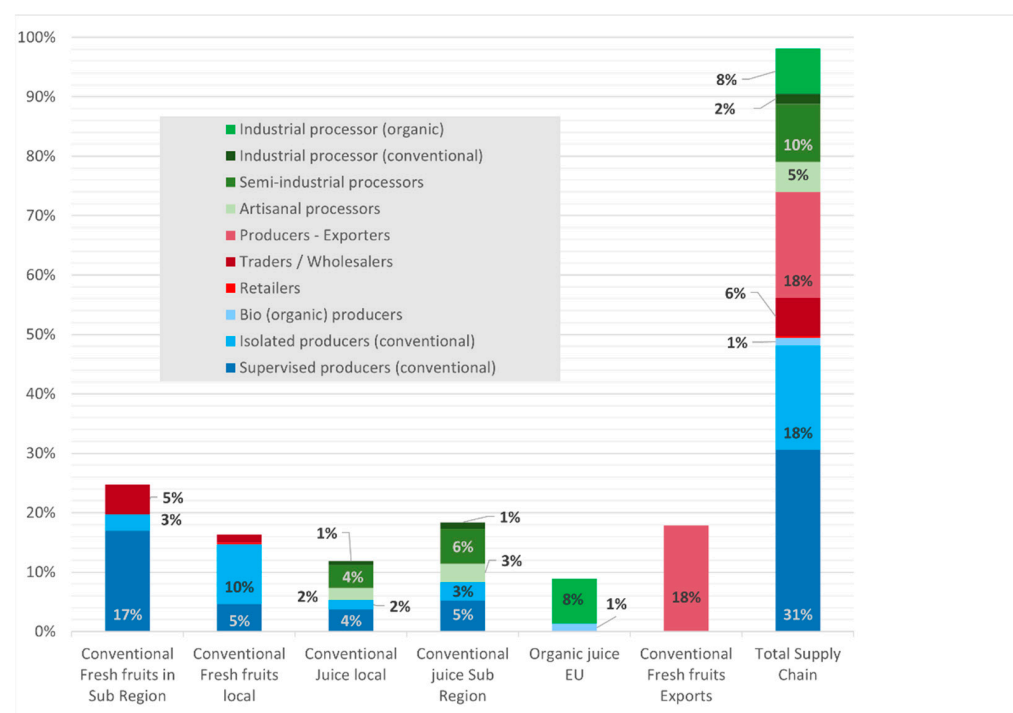


Figure 3. Value-added shares per supply chain channels.

Beyond the notion of value added generated in the supply chain, which is marginal at the level of the Gross National Product (less than 2%), it is relevant to measure the rate of integration (The ratio of the value of total production on the value of total imports) of the supply chain into the national economy. This calculation was carried out for the 6 analyzed channels and the results show that the overall supply chain rate of integration is 55%, meaning that 45% of the value of the supply chain is created with imported goods (not domestic products). Complementarily, the rate of integration of channels with processing in juice is low (37% for regional conventional juice and 38% for local conventional juice). The supply chain is heavily dependent on official imports relatively to official exports, implying a negative balance of trade of the supply chain.

Other indicators of the impact of the supply chain on the national economy consist in the analysis of the direct and indirect effects of the supply chain in the economy. It is measured by using the *Effects Method* (referred to in [34] pp. 111–145).

The analysis of the direct and indirect effects of the supply chain (Figure 4) shows that the total production value of the pineapple supply chain is more than 31 billion FCFA, but that only a little more than half of this value constitutes the value added directly generated by operations in the supply chain. It shows and confirms the fact that imported intermediate consumption (products and services) (therefore non-domestic) used in the supply chain is too significant and it reduces the positive impact of the value added directly generated by the supply chain on the national economy.

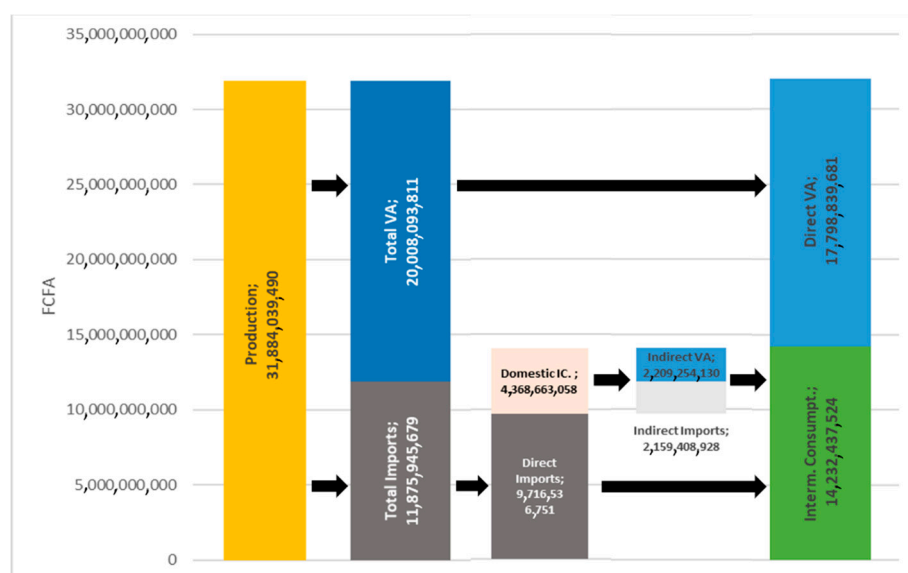
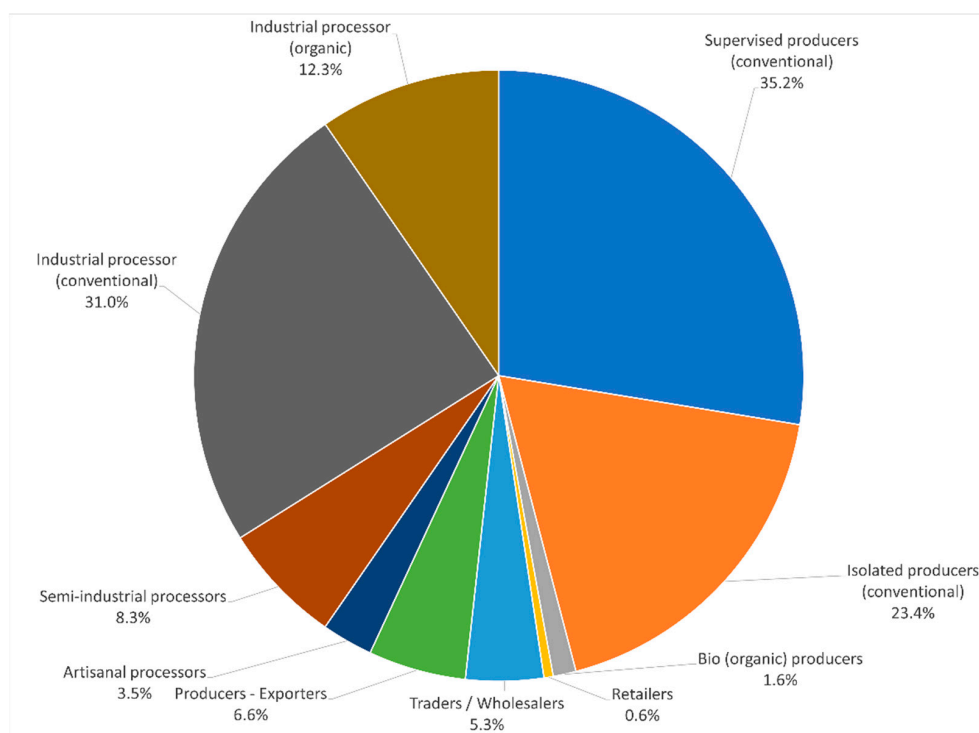


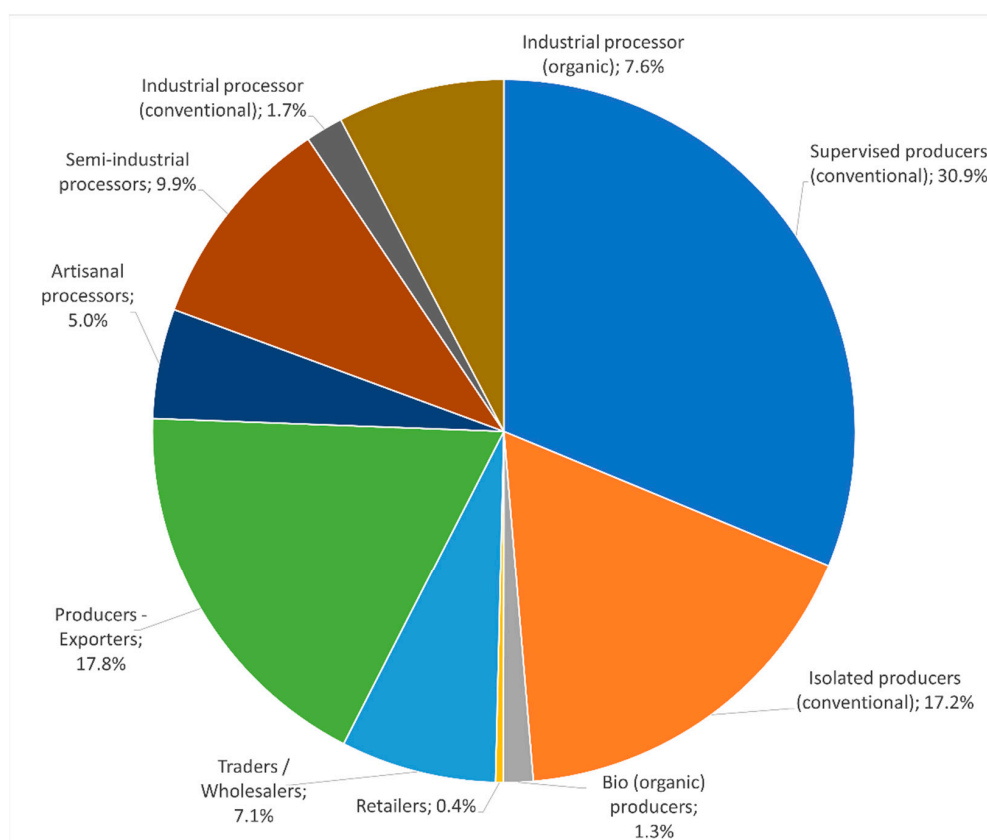
Figure 4. Measures of direct and indirect effects of the supply chain in the national economy (in Francs CFA).

This leads to analyzing indicators on the impacts of the supply chain within the international economy. The distinction was made between tradable and non-tradable goods and services in intermediate consumptions to measure the Nominal Protection Coefficient (NPC) and the Domestic Resource Cost Ratio (DRC). The estimate of the Nominal Protection Coefficient (NPC) is 0.9. This means that the supply chain actors receive slightly less income from their operations than what they would receive in the international market. The Domestic Resource Cost Ratio (DRC) is about 0.5. It shows that the supply chain has a comparative advantage in terms of the production factors it uses. Domestic resources used in the supply chain are cheaper than at their international prices. The pineapple supply chain in Benin therefore has a comparative advantage because it uses less production factors (or at a lower value than the ones at international prices) than it generates value added [34,49,50]. It confirms that the availability of intermediate products and services on the domestic market as substitutes to the imported ones would contribute to a sustainable growth in direct value added.

In terms of growth (through benefits and/or value added) inclusiveness (Figure 5a,b), producers in conventional channels are the most numerous but they suffer from a significant difference in farm gate prices of fresh pineapple fruits. Their individual income compared to producers in the other channels (organic or exports) is low too. Isolated producers, having informal relationships with the other levels of the supply chain, are more likely to have lower yields because of a lack of agricultural inputs, labor and techniques. Additionally, they sell pineapple at lower prices to access markets. Young people are more likely to take part as isolated producers because they are cautiously approaching pineapple farming, starting first with small production areas. Women are increasingly involved in production, but they are mainly operating locally as retailers and saleswomen.



(a)



(b)

Figure 5. Shares of the net benefits (a) and value added (b) by main groups of actors in the supply chain.

The results of the economic analysis show that an activity in the supply chain is beneficial to all stakeholders. Each actor and each level generate added value, even if it is not of the same extent for all. Overall, the supply chain creates more than FCFA 17 billion in direct value added, which is economically significant for the country. Nevertheless, in this supply chain, the observation is made that too many intermediate goods and services are imported to the detriment of the integration of the supply chain into the national economy and its balance of trade. Finally, at the level of the international economy, the pineapple supply chain in Benin has a comparative advantage, both in terms of production factors and the income generated.

The subdivision of the overall supply chain into 6 channels makes it possible to highlight the economic specificities of each, as well as the elements and actors being the most vulnerable to various economic effects. The main channel is characterized by a conventional production of pineapples marketed as fresh fruit in the sub-region. It generates 25% of the global value added for a use of 55% of national production. Another conventional channel corresponds to fresh fruit produced in a conventional manner and marketed in the local (national) market. It generates 16% of the global value added for a use of 15% of national production. The third channel represents the conventional production sub-sector with processing of fruits into juice and trade in the country. It generates 12% of the global value added for a use of 11% of national production. The fourth one consists in the conventional production sub-sector with transformation of fruit into juice and marketing of juice in the sub-region. It generates 19% of the global value added for a use of 17% of national production. The two last channels, the organic fresh fruits and juice to Europe and the conventional fresh fruits for exports are not illustrative and easy to quantify. According to the study, there are representing around 2% of the overall production of pineapple in Benin.

Consequently, there is a real interest in stimulating the development of the local and regional channels of the supply chain as it currently exists and by reinforcing the substitution of intermediate goods and services with local ones. To make the supply chain sustainable, care must be taken to improve yields and reduce losses, while developing processing by promoting shorter circuits and targeting local and regional markets. These markets are very promising in terms of demand for fresh fruit and juice and they are much less demanding than the Western markets, which require huge investments.

4.1.3. The Social Analysis

In terms of working conditions, it has been observed that most employment contracts are verbal and based on trust. Child labor is not widespread. The supply chain is attractive to investors (business relationships, innovations), which is encouraging for already-involved actors and potential new entrants [51–53].

According to access to land, the proportion of land inherited by men and women is 88% and 12%, respectively. However, women have more and more opportunities to buy small lots of land to start pineapple farming [54].

Gender equality is unbalanced mainly in production (10% of women) and processing (40% of women), while there is more than 80% of women operating as retailers. Nevertheless, gender-based discrimination is low as a significant proportion of women participate in decision-making and management at various levels of the supply chain [55].

In the field of food and nutrition, the actors of the pineapple supply chain benefit from a high level of food availability and accessibility (thanks to widespread practice of agriculture, proximity to Cotonou where the food surplus goes, wide choice of food) [13,56].

The supply chain is organised and structured by professional groups at each stage. There are various associations and professional groups bringing together actors of the same channel or level of the supply chain. Nevertheless, as described in the typology of producers, around 60% of producers (men, women, and young people) do not belong to any professional organizations.

The living conditions of the actors are gradually improving (better access to health services and education, improved quality of housing). Because their activities in the pineapple supply chain is generating benefits, actors have good living conditions. In addition, at the producer level, investing in this farming activity requires having funds available to buy land and/or produce pineapple (with a return on investment at least 18 months later) [13,56–59].

As shown in the social profile presented in Figure 6, the analysis of the social thematic has demonstrated that the pineapple supply chain in Benin is socially sustainable. Stakeholders' activities in the pineapple supply chain have positive social and inclusiveness impacts. It will be more and more efficient if the main constraints identified such as access to productive resources, access to credit, lack of labor force at the farm level, financing of pineapple juice processing and packaging equipment, regional advocacy to facilitate access for traders at the regional level and strengthening of logistical conditions for the export of pineapple fruits in the region. The production level is the most vulnerable. Indeed, the various analyses highlight the fact that the yields obtained are positively correlated with the availability of labor, agricultural equipment and inputs. Providing producers with more appropriate agricultural and technical advice would increase yields without increasing the number of inputs used. The development of cooperatives and coordination would be favorable to the sector (filling the lack of labor, facilitating access to suitable inputs, setting up formal contracts, technical mastery, etc.) [58].

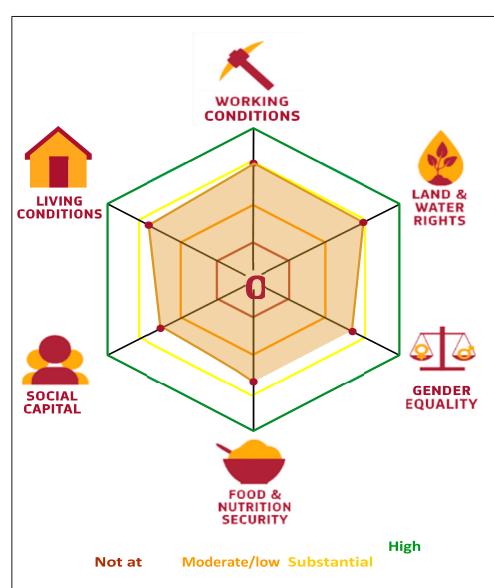


Figure 6. Pineapple supply chain of Benin Social Profile [59].

4.1.4. The Environmental Analysis

The analysis of the environmental pillars of the supply chain is based on the assessment of impacts and damage caused on natural resources, the quality of the ecosystems and human health, throughout the life cycle of the pineapple fresh fruit or juice, using the Life Cycle Analysis (LCA) method. The LCA method of this study has been applied by an expert of the Centre de coopération internationale en recherche agronomique (CIRAD).

The environmental analysis studied all the identified 6 channels (Figure 1). The quantification of potential environmental impacts was measured for activities that took place within the country's border. Since there are 2 products (fresh fruits and juice), environmental damages have been measured by 1 kg of equivalent pineapple. The primary agricultural production of pineapple is the major contributor to the environmental damage caused by the supply chain. In Figure 7, it can be read that damage to human health is mainly due to fertilizer emissions emitted at their application at the primary production phase. Ecosystem quality is impacted for around 70% by land use at smallholders' level. Finally, resource

depletion is for 40% due to the manufacturing of fertilizers and for 20% for packaging in processing [59].

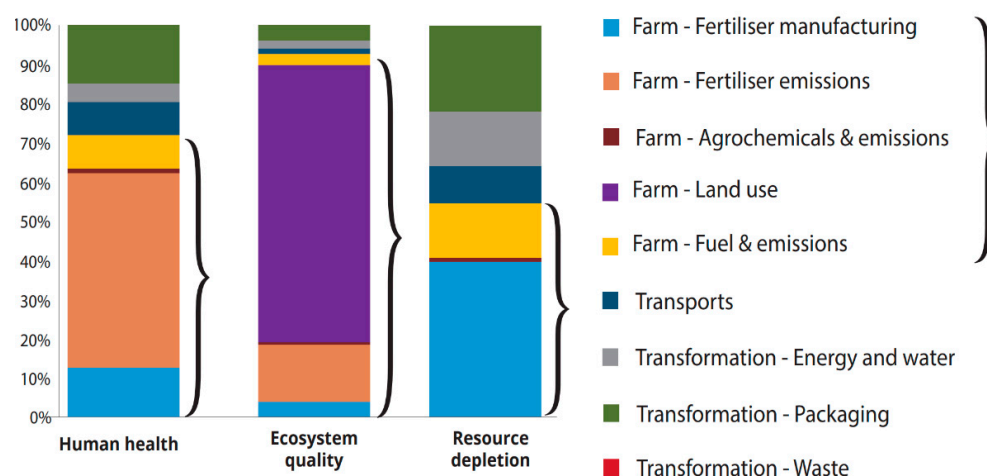


Figure 7. Contribution of the supply chain stages to the damages in 1 kg of equivalent pineapple [59].

Comparing to fresh fruit channels, it is observed that 1 kg of fresh pineapple exported to the EU contributes the most damage to human health, mainly due to the carton used for packaging. Then, 1 kg of fresh fruits exported to the sub-region negatively impacts the ecosystem quality and contributes to resource depletion mainly because of the fuel used for road transport. Fresh pineapple consumed on Benin's local market has the lowest contribution to the three areas of protection [59].

For the pineapple juice channels, organic juice exported to the EU contributes the least (per kg of pineapple processed) to human health damage and to ecosystem quality. It is explained by the lower emissions emitted by organic producers. However, the organic channel has significant impacts on resource depletion because of fuel used for transport and plastic bags used in packaging. The juice channel's environmental performance is linked to the origin of the pineapple used by processors, the conversion rate from fruit to juice, and the energy and packaging. Environmental damages caused by the fresh fruits and juice exports increase significantly when the freight transport's impact beyond Benin's borders is considered [59].

Comparing pineapple production systems shows that organic production has significantly less impact than conventional production per cultivated hectare. Globally, in Figure 8, we can see that, per kg of pineapple, the most significant difference of impact is about resource depletion. The impact on human health has a difference of 40%, and there is a minimal difference of impact on the ecosystem. It is explained by the fact that, in Benin, the conventional system of production is functioning similarly to the organic one (damages are higher for conventional pineapple due to the use of nitrogen fertilizer) [59].

In terms of the environmental impacts, results of the Life Cycle Assessment of the 6 channels led to the same conclusions encouraging a more efficient production level with the major contributor to the damage caused by the overall supply chain on human health, ecosystems, and resources, but also, the shortening of the supply chain to minimize transports' (trucks and freight) environmental impact [59]. Details of results are available in the supplementary material mentioned [58] and in the summary of the study [59].

Because of the VCA4D methodology application on the pineapple supply chain in Benin, its growth generation is proven and measured. End users and market opportunities for the overall supply chain development are identified. Nevertheless, economic growth can be enhanced by shortening the supply chain and its imports as much as possible, and this is beneficial at all operational levels and for all actors generating profit and value added in the supply chain. It should be realized that a minimal part of the primary production of pineapple is consumed and/or processed in the country.

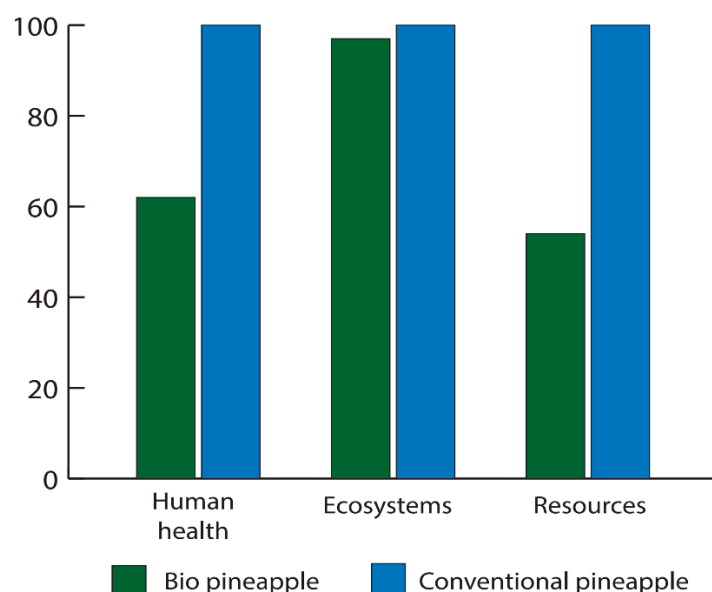


Figure 8. Comparison of damages in 1 kg of pineapple according to the production systems [59].

The alignment of those economic results with social and environmental ones brings the findings that encouraging a more effective production in the agricultural sector should be done in parallel with developing better processing capacities in the secondary sector. This sector has even greater potential for generating added value and sustainability of Benin's pineapple supply chain.

4.2. The VCA4D Method Applied to the Pineapple Supply Chain in Togo

According to the summary of the VCA4D report of the pineapple value chain analysis in Togo [60], globally, pineapple is the second most cultivated exotic fruit after banana in the world. In Togo, other crops had received more support (coffee, cocoa, cotton) and it was not until 2015 that the Government, supported by GIZ, revived this value chain (VC), with significant results.

Togo has a comparative advantage in organic pineapple production and the Smooth Cayenne variety, which is sought after in niche markets. The sale of fresh fruit and pineapple processing in micro, small and medium enterprises (MSMEs) offers good prospects for development. These opportunities are essential for the country: income for farmers and traders, employment for young people, and exports. Nevertheless, processed products are competitive and dominated by countries such as Ghana and the Ivory Coast.

4.2.1. The Functional Analysis

The functional analysis provided a representation of the supply chain as presented in Figure 9.

It has been estimated that pineapple is grown by some 3200 producers. Production was close to 30,000 tons in 2018, 65% of which was organic pineapple and 35% conventional pineapple. The processing sector is proliferating with an increase of the MSMEs number and 32% of pineapple is exported fresh by a dozen companies, while around 30 companies are currently producing more than 1 million L of pineapple juice (200,000 L of organic) and 476 tons of dried pineapple. More than 60% of pineapple is exported fresh or processed products, mainly in Europe for organic products (France, Germany, Switzerland, Italy) or to the regional market (Burkina Faso, Ghana, Mali, Niger). Imports are minimal (some limited pineapple from Benin to the north) [60].

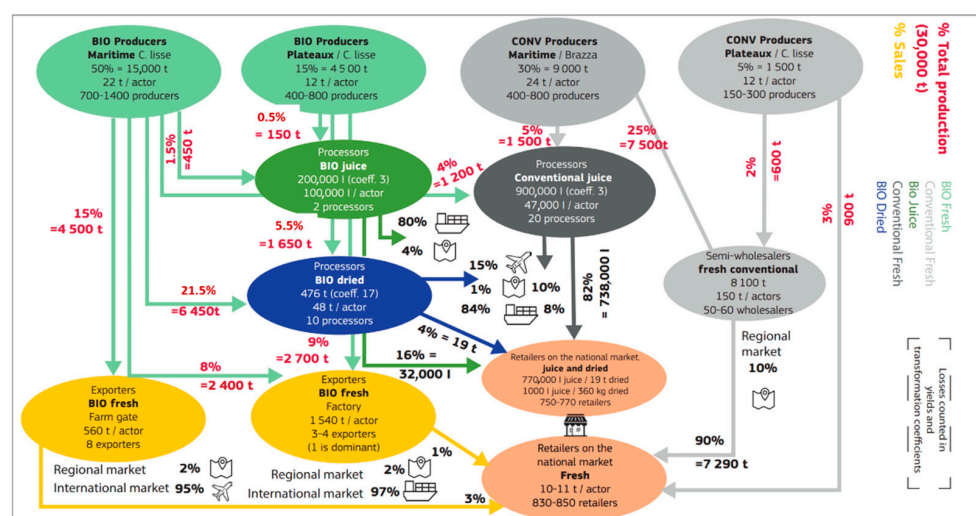


Figure 9. Pineapple Supply Chain in Togo [60].

4.2.2. The Economic Analysis

The economic analysis showed that the annual individual net income of pineapple producers varies between FCFA 403,000 and FCFA 1,388,000, depending on their location, their cropping system (organic or conventional), their cultivation practices (renewal of plant material, soil preparation work) and the cultivated variety [60].

The total value of the production measured was FCFA 7072 million in 2018, 69% of which corresponds to the value-added and 31% to intermediate consumptions (IC). Of these ICs, 34% are imports and 66% are domestic ICs. Cardboard packaging accounts for 63% of the imported IC needed. The direct VA amounted to FCFA 4908 million, and the domestic ICs generated FCFA 1142 million of indirect VA, so the total VA of the pineapple supply chain amounts to FCFA 6050 million. Despite a high integration rate in the national economy (in the order of 86%), the national economic growth's supply chain contribution is marginal. The Domestic Resource Cost ratio is 0.6, illustrating that the economic wealth created, measured at international prices, is higher than the cost of domestic resources used. This indicator demonstrates that the supply chain is economically efficient. Globally, it has a comparative advantage that attracts companies' interest, especially foreign ones, to invest in the processing of pineapple and in organic pineapple, which is highly sought after on the international market [60].

4.2.3. The Social Analysis

The social profile obtained is given in Figure 10. The pineapple value chain in Togo has positive social effects in gender equality, food and nutrition security and social capital. The situation is less satisfactory concerning living conditions, working conditions and access to land. One of the issues that threatens the sustainability of the value chain is its unattractiveness to young people.

4.2.4. The Environmental Analysis

In terms of environmental impacts, the life cycle analysis on pineapple compared 5 fresh pineapple sub-chains, 2 juice sub-chains (bio from the Maritime area, exported by boat; and conventional from Maritime area, local market) and 2 dried pineapple sub-chains (Maritime area, bio, exported by boat; and Plateaux area, bio, exported by boat). The impact assessment on resource depletion gives the following. In the fresh sub-chain, conventional pineapple destined for regional markets has the highest impact due to chemical inputs and the long-distance transport from Lomé to the border with Burkina Faso. The juice sub-chain is also the conventional product that generates the most impact because of chemical inputs. The impacts of processing and transport are virtually the same for organic juice and conventional juice. For the dried product sub-chain, the Plateaux area's product

has a higher impact due to the distance and volume of fresh pineapple to be supplied to the processors in Lomé. The ecosystem quality assessment explained that for fresh and dried sub-chains, pineapple from the Plateaux area generates the highest impact due to low yields (soil use). It is followed by Maritime area fresh pineapple destined for regional markets which, despite its high yield, uses more soil because of the long-distance transport losses towards the Sahelian countries. As for the juice sub-chain, the conventional product has the highest impact because of chemical inputs. For processing, natural gas, glass and cardboard packaging are damaging the quality of ecosystems. Finally, about human health, in the fresh sub-chain, conventional pineapple traded on the regional market has the highest impact due to the use of chemical fertilizers, pesticides and emissions from the use of fossil fuel during transportation. Not surprisingly, the impact on human health is also higher for conventional juice (toxicity). For the dried product sub-chain, the impact of the product from the Plateaux area is the highest because of its low yield and emissions related to the use of fossil fuels for transport [60].

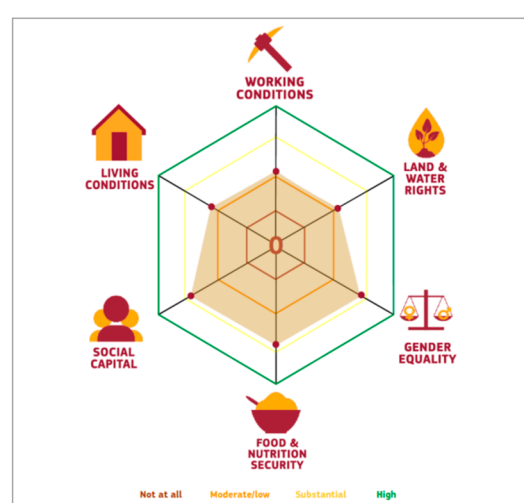


Figure 10. Pineapple Supply Chain in Togo social profile [60].

5. Discussion

The VCA4D approach draws its center of interest above all because it is intended to be an almost exhaustive analytical framework. It has made an effort to enhance other existing approaches in their qualitative and quantitative dimensions. It makes it compulsory to operate a rigorous approach on all areas of analysis systematized in the approach. The other supply chain analysis approaches give themselves the freedom of partial analysis depending on the centers of interest targeted, one or two sustainable development dimensions, or a strategical objective. The VCA4D approach requires an integrated analysis of the functional, socioeconomic, environmental aspects, etc.

Nevertheless, comparing the results of the VCA4D analysis of the pineapple supply chain in Benin, with that of pineapple in Togo, shows that the same analysis tools were applied. The interpretation of the results strongly depends on the contextual and functional analysis and the decision-makers' strategy and the application of the tools by the team of researchers. The main difference in the use of tools and the presentation of results adopted by the experts can be observed at environmental analysis and the LCA level. Indeed, we see that the LCA has not been applied in the same way, although it has been carried out on supply chains with very similar operations. To date, almost 30 VCA4D analyses have been conducted in developing and emerging countries. However, the diversity of context, commodity, and teams of experts led us to base the discussions in this article on the application and replicability of the VCA4D method (also concerning the evolution of guides and frameworks discussed in the review of the literature on this subject. Obtaining an exhaustive and correct functional analysis will lead to obtaining coherent results according

to the context. Later, it will allow comparison to benchmarks and supply chains over time and between them. This finding is well illustrated because, except for a few indicators, neighboring countries' pineapple supply chains are not comparable while analyzed with the same method.

5.1. Limits of the VCA4D Method

The VCA4D method is a tedious one requiring a minimum of means and multidisciplinary resources to initiate data collection and multidimensional analyses. Unlike many approaches, it is challenging to settle for partial analyses, which prioritize in-depth analysis of a few areas to the detriment of others. It is more comfortable on supply chains that already have many exploratory analysis initiatives and data capitalized beforehand. It is primarily suited to the context where quantitative data from certified sources are available. Some analyses may appear hypothetical by default of reliable data and/or comparable to other sources.

Indeed, we have addressed the importance of considering the context in which interventions must be implemented in favor of sustainable development. The contextual elements are qualitative and quantitative. VCA4D provides a framework through functional analysis to put the supply chain's concrete functioning in a broader context. Also, VCA4D strongly encourages the collection of reliable and recent data on the supply chains analyzed. However, both the experts' lack of objectivity and the weak robustness of data collected leave too much room for estimates. It can efficiently conduct to a poor, even a false representation of the supply chain from the study's start. The empirical foundations of functional analysis run the risk of inducing biases in the three analyses carried out in a complementary manner.

The economic analysis tools used are well known and sufficiently developed to be applied in all contexts, the thematic of operations, whatever the country, the micro or macro level of the analysis, the type of actor, etc. The results obtained are relevant because they demonstrate, thanks to quantitative indicators, the interest of actors in operating in a supply chain and the generation of growth that this generates at their level, at more collective levels and even at the national economy.

Social analysis is inevitably based on more qualitative elements. Combined with the financial results, the social analysis demonstrates whether inclusiveness is present in the supply chain regarding income and added value. Qualitative reflection is requested on gender aspects, working conditions, young people, access to land and water, which is very relevant. The problem with its application in an emerging or developing country context is that the themes it addresses are present in the field but do not meet the challenges actors face in the field and their operation. As soon as the themes are more of an institutional order, they do not feel concerned because it will not bring any solution in their everyday life.

The same difficulty arises for environmental analysis. Indeed, LCA's use as a tool to assess a supply chain's environmental impacts is beneficial. Nevertheless, the strategic questions on the impacts on human health, ecosystems, and resource depletion are too global to meet stakeholders' objectives and challenges in an emerging or developing country. LCA analysis results are relevant for an institutional decision-maker but not for a stakeholder.

These VCA4D method limits demonstrate that it has the merit of offering a framework in which existing multidisciplinary tools make it possible to assess an agricultural supply chain's sustainability according to the three pillars of sustainable development. In light of the evolution of the sustainability assessment method applied to supply chains, VCA4D offers exciting results. However, this method helps make strategic decisions for sustainable development due to its shortcomings, but at the institutional and political level.

5.2. Improvements Suggested for Further Supply Chains Sustainability Analyses

Thinking about sustainable development goals and how to achieve them is continuously evolving. As a result, the scientific community, researchers, and decision-makers are continuously seeking dynamic solutions to assess the impacts of interventions on economic, social and environmental sustainability. Besides, the contexts for applying sustainability assessment methods are very disparate and involve varied opportunities and interventions.

The place given to specific analyses relating to the pro-poor, inclusive market dimensions as a lever for increasing vulnerable groups' income is still insufficient. In other words, the rural and growth development analysis dimensions must be further enriched with increased attention to identifying levers of access to services by categories of vulnerable actors to facilitate their market share and ultimately increase their income. Also, approaches must consider the areas of analysis of the possibilities offered by e-agriculture technologies on value chains being the current challenges of e-agriculture strategies to understand the costs of e-agriculture; "opportunities and cost-benefit analyses inherent in technological options."

In terms of sustainability, to meet sustainable development objectives and 5 Ps in a more integrated manner, the approaches should propose a more participatory analytical process with stakeholders and allow less laxity when representing the supply chain's functioning. Indeed, analyses quality and relevance strongly depend on the functional analysis and data collected.

Finally, as underlined in the literature review on the various key concepts included in an agricultural supply chain analysis, it would be relevant for the assessment frameworks to integrate better the ISO standards developed to strengthen the procedural and qualitative aspects of development. This is even more important in a decision-making context to promote sustainable development, often synonymous with access to broader markets for agricultural products.

6. Conclusions

The VCA4D methodology seeks to combine efforts to contextualize and develop sustainability assessment tools to support sustainable interventions in agricultural supply chains in emerging or developing countries. However, although the methodology offers multidisciplinary tools and brings evidence-based elements to support decision-making, several limitations and gaps remain.

While it has limits, a VCA4D analysis includes analytical processes allowing identifying supply chain's gaps and malfunctioning, as well as the limits in stakeholders' access to the various services (inputs, equipment, quality approach, governance, financing, interprofessional organization, etc.) that are essential for optimizing competitiveness on the markets. The VCA4D analysis allows decision-makers to have evidence-based elements on support interventions, services and governance in the supply chain to implement adequate inclusive and sustainable interventions. To better meet society's needs and sustainable development objectives in developing countries, sustainability analyses of supply chains must strengthen the participatory aspects. Previous analytical frameworks have demonstrated it, and the VCA4D framework lacks too, that it is also essential to be relevant and exhaustive in the contextualization and rigorous information gathering. It will allow laying solid foundations and structured for economic, social and environmental analysis frameworks.

The results of these multidisciplinary analyses will be more robust. It will allow trade-offs in strategic decisions and comparisons between analyses and benchmarks to better support sustainable development decisions.

Supplementary Materials: Desclee, D., Kinha, C., Payen, S., Sohinto, D., Govindin, JC. 2019. Analyse de la chaîne de valeur de l'ananas au Bénin. Rapport pour l'Union Européenne, DG-DEVCO. Value Chain Analysis for Development Project (VCA4D CTR 2016/375-804), 154p + annexes. A summary (in English) of the full report is downloadable at: <https://europa.eu/capacity4dev/file/104677/download?token=hWOoWsx0>.

Author Contributions: Conceptualisation, D.D., methodology, D.D. (D.D. was initially involved in the development of the overall VCA4D methodology); data and resources collection, curation and economic analysis were conducted by D.D., D.S. and F.P.; writing, D.D. This paper was written by D.D. based on the collaborative study and research report done on the pineapple supply chain in Benin (April 2019 to November 2019), for which D.D. was the team leader and economic expert, D.S. and F.P. were national and supply chain experts.; review, D.D., D.S. All authors have read and agreed to the published version of the manuscript.

Funding: The VCA4D Programme and studies are funded by the European Commission, DEVCO (VCA4D CTR 2016/375-804).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and the European Union Research Ethics (Charter of Fundamental Rights of the European Union, Official Journal of the European Union (30.3.2010)).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the initial study of the pineapple supply chain in Benin. and GDPR of the European Commission have been applied (The General Data Protection Regulation (EU) 2016/679).

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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