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Modern Agricultural Machinery and Agri-Food Supply Chain Management for Efficient Agricultural Development in Africa: A Case Study of Burkina Faso

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Abstract

This paper delves into the critical role of modern agricultural machinery and Agri-Food Supply Chain Management (AFSCM) in fostering efficient agricultural development in Africa, with Burkina Faso as a focal point. The research aims to provide a comprehensive understanding of the contributions of modern agricultural production machinery and strategic supply chain management in the specific context of Burkina Faso. Through an in-depth case study approach, the study analyses the adoption patterns and effectiveness of modern agricultural machinery, contrasting them with traditional and semi-mechanized methods employed by Burkinabe farmers. Additionally, it examines the current state of AFSCM implementation in the agricultural sector and food supply chain in Burkina Faso. The findings of this research contribute valuable insights into the dynamics of agricultural development in Burkina Faso and further in Africa, offering practical recommendations for optimizing the synergy between modern machinery and efficient supply chain management to enhance overall productivity and sustainability in the agricultural sector and the improvement of Burkinabe food chain.

Subject Areas

Economy and Management

Keywords

Agri-Food Supply Chain Management (AFSCM), Modern Agricultural Machinery (MAM), Logistics, Supply Chain Management (SCM)

1. Introduction

Over the years, several sectors of activity have undergone significant change through the adoption and creation of modern machinery and also organizational methods. However, the agricultural sector has not stayed insignificant in the face of this development. If manual labor has given way to mechanics, it is easy today to see the evolution of the agricultural sector from traditional to modern in some developed countries. In Africa, Most countries have a weak scientific and institutional foundation to revolutionize their agricultural practices. Long-term investments are required to set up and build the scientific and institutional foundation for modern agriculture. This is a tall order, but this is what some countries like the USA accomplished from 1860 to 1912, what Japan did from 1868 to 1914, and what many countries in Asia and Latin America have accomplished over the past 40 years [1] [2].

Developed countries have opted for modern methods of farming combined with efficient management through logistics and supply chain management. The agri-food supply chain management involves a series of activities and processes during the flow of food products from farm to fork [3] [4]. With demographic growth, the demand for food products continues to increase year by year, leading to an inflationary impact on the prices of imported food commodities in developing countries. The global population is presumed to reach 9.70 billion, and the demand for food is prognosticated to rise in the span of 59.0 to 98.0 percent by the year 2050 [5] [6]. To prevent this situation, countries like Burkina Faso should then focus on local production while combining modern agricultural production techniques to allow all social strata to feed themselves properly and thus ensure food security.

Burkina Faso experiences low and variable rainfalls, land degradation, deforestation and desertification. Despite the harsh climate, Burkina Faso's agriculture sector continues to generate roughly a third of the country's GDP and employs 80 percent of the population [7]. Despite the number of people employed in the Burkinabe agricultural sector, yields are quite low, and the country is unable to achieve food self-sufficiency. Indeed, the type of agriculture practiced in Burkina Faso is still traditional because more than 50% of farmers use human power in small areas, and the rest practice semi-modern agriculture. In the year 2022, Burkina Faso's GDP saw a contribution of approximately 20.4 percent from agriculture, 29.33 percent from the industry, and the services sector was the best contributor with 40.92 percent [8]. This observation is alarming and highlights the fragility of the Burkinabe agricultural sector despite the number of people it employs.

The agricultural landscape in Burkina Faso is marked by a range of challenges that hinder its full potential. These challenges include unpredictable climate patterns, limited access to modern farming equipment, inadequate irrigation infrastructure, and fragmented supply chains. These realities lead to further reflections and insights for us to look for solutions for efficient farming and the well-being

of populations.

In this study, we will explore how modern agricultural machinery combined with an efficient AFSCM can solve the problem of agricultural development in Burkina Faso by improving productivity, and supporting more complex operations while reducing production costs. To fulfill the purpose of our study, two issues should be addressed: 1) the modernization of agricultural equipment: a solution for optimal production? and 2) what is the contribution of AFSCM in the agricultural sector?

The answers to these questions will, in addition to the work carried out by researchers beforehand in the field of agriculture, allow us to better understand the challenges faced by the agricultural sector and the Burkinabe food chain. This understanding will enable us to make suggestions and contributions for the development of these sectors in Burkina and beyond, extending into Africa.

The rest of the paper is structured as a Section 2 literature review, Section 3 methods and materials, Section 4 results, Section 5 discussion, and Section 6 conclusion.

2. Literature Review

2.1. Agricultural Machinery

The development of the agricultural sector and the corresponding operating income has consistently been a focal point of interest. Prior research has predominantly concentrated on examining strategies to enhance agricultural operating income.

Considerable research has been conducted on the influence of agricultural machinery on agricultural production [9] [10], encompassing two primary dimensions: cost reduction and enhancements in quality and efficiency.

First and foremost, the escalating costs of labor stand out as a key factor contributing to the decline in agricultural profitability [9] [11]. The cost of servicing agricultural machinery is usually less than labor costs [9] [12]. The adoption of agricultural machinery by farmers can result in significant reductions in labor expenses [9]. Moreover, agricultural machinery can efficiently undertake tasks such as land leveling and preparation, thereby enhancing the overall utilization of agricultural resources and diminishing the necessity for weed and insect pest control [9] [13]. Additionally, agricultural mechanization facilitates combined fertilization and sowing, ensuring not only precise sowing but also reducing the expenses associated with seeds and fertilizers [9] [14].

The second dimension involves enhancing quality and boosting efficiency, primarily manifested through heightened agricultural production and improved product quality. Agricultural machinery, through operations like leveling, land preparation, deep turning, and deep scarification [9] [15], can enhance land quality more effectively than traditional manual and livestock methods, particularly in the conversion of medium- and low-yield fields [9] [16]. The utilization of agricultural machinery can enhance the frequency of multiple cropping on

cultivated land, offering the potential for multiple crop cycles within a single year. This, in turn, leads to improved production capacity and increased land output rates [9] [17].

Mechanical irrigation and drainage, machinery for dry farming, and mechanical spraying prove effective in mitigating risks associated with droughts, floods, weeds, and insect pests [9]. Furthermore, the implementation of mechanical sowing and field management ensures a more uniform crop distribution and fosters growth [9] [18], while the utilization of standardized agricultural machinery helps decrease agricultural losses and enhance overall product quality [9] [19].

According to the views of [9] [20] [21], enhancing the advocacy for advanced agricultural machinery technology is considered a strategy to elevate the standard of green and high-quality agricultural development.

Through these researchers, we can retain the impact of the use of modern machines in agriculture which not only make it possible to produce in large areas in quantity and quality but also to bring more in terms of income to producers. It is also important in this study to highlight the studies previously conducted in the Agri-Food Supply Chain Management sector that support the agricultural sector in addition to the machines used in pre-production, production, and post-production management, to bring added value to the agricultural sector and the food chain. Most of these researchers describe the problems encountered in the agri-food sector, which will be addressed in the remainder of the study.

2.2. Agri-Food Supply Chain Management

The agriculture food supply chain (AFSC) encompasses the stages involved in the production and delivery of agricultural produce (Agri-produce) from its origin to the point of consumption [22].

Every step within the AFSC contributes a distinct value to the ultimate product. The production stage yields the raw produce, which undergoes processing at the subsequent stage. Following processing, the produce is stored in distribution centers before being disseminated to diverse retailers. Consumers acquire the produce from these retailers. The array of stakeholders engaged in AFSC includes farmers, consumers, agricultural suppliers, food processors and distributors, non-government organizations (NGOs), national and international agricultural bodies, government entities, and affiliated institutions, among others. [22] [23]. Every participant in AFSC encounters challenges in managing the diverse associated activities, as detailed in discussions by [22] [24]. Farmers confront issues such as inadequate availability of financial and human resources, fertilizers, pesticides, raw materials, information sharing, and potential security threats. Additionally, farmers grapple with difficulties in marketing, transportation, receiving a fair share in consumer prices, limited negotiating power, and the lack of infrastructure facilities like refrigerated warehouses [22] [25].

Furthermore, farmers are significantly affected by climate conditions in various ways, encompassing alterations in average rainfall, climate extremes (e.g., heat waves), temperature fluctuations, pests and diseases, changes in atmospheric CO_2 and ground-level ozone concentrations, shifts in sea level, and variations in the nutritional value of food. Intermediaries encounter challenges such as warehouse management, coping with the perishable nature of produce, limited information about prevailing consumer prices, and inconsistencies in the supply and demand for agricultural products. Consumers contend with issues related to safety and quality, fluctuations in product prices, and a lack of standardization concerning agricultural produce.

Furthermore, contemporary AFSC involves significant energy consumption along with various economic, environmental, and social concerns [22] [26].

Addressing certain challenges within AFSC could be achieved through the effective design of the food logistics network. This involves optimizing the location of supply chain nodes, embracing sustainable options throughout all stages of food distribution, enhancing food distribution routes, and restructuring the food logistics chain network for improved efficiency, as discussed by [22] [27]. In the literature, the term "Agricultural Food Supply Chain Network (AFSCN) or Agricultural Food Distribution Network" is also used to refer to a food logistics network [28]. The Agricultural Food Supply Chain Network (AFSCN) manages the transfer of produce among stakeholders. However, designing the AFSCN is intricate because distinct structures are necessary for various products. Perishable goods, with their limited shelf life, require specific arrangements to counteract high deterioration rates that can result in a decline in the quality of the produce.

3. Methods and Materials

This research aims to validate or refute theories that have previously shed light on the subject. Considering data availability, data from 1999 to 2023 have been used depending on our interests either in AFSCM or modern agricultural machines. Consequently, a deductive approach was employed throughout the study. This deductive methodology was chosen as we initiated the research with a theoretical framework relevant to the subject, serving as the foundation for our empirical findings. The elements identified in the case study showed the relevance of the research questions and therefore showed that this study also has an inductive method.

The rationale underlying the case study is that, at times, a comprehensive understanding of the genuine interplay of variables or events can only be gained by closely examining a practical real-life instance. To ensure more dependable research findings, the case study must be meticulously designed. The unit of analysis and selection of cases were the major categories of the case study design. Accordingly, the unit of analysis of this research is the key to the development of Burkina Faso agricultural sector. For this study, the 13 regions of Burkina Faso

were considered and 201 actors in the sector of agriculture, logistics and Supply Chain were involved for the smooth running of this study.

By interviewing, observing, and using questionnaires, the study used a comprehensive research method. Research and findings were executed with a qualitative approach.

A survey questionnaire (https://forms.gle/7wDQdxAXPWJZv3f78) was sent to over 200 actors in the sectors cited above, utilizing the Google Forms platform but only 201 actors were considered in this study. The questionnaire was designed taking into account the sectors relevant to this study. The survey focused on data pertaining to the Burkinabe agricultural sector in general, as well as Agri-food SCM in Burkina Faso, in order to gather all necessary information for the successful progression of the study. The objective was to gather insights into their perspectives on the agricultural sector, as well as the role of logistics within it.

The interviews involved individuals randomly selected from the sample of the questionnaire conducted beforehand, for which we took care to collect respondents' phone numbers. During the telephone interviews, we inquired about how they perceived the received questionnaires, and an open conversation was initiated to learn more about the agricultural techniques of the interviewees and the challenges they face both in terms of agriculture and in the food chain.

Additionally, on-site observations were conducted on farms in the Shanxi province of China, focusing on the equipment utilized by local farmers.

To derive the outcomes of this study, all collected data underwent processing based on their respective types. The interviews and questionnaires conducted in Burkina Faso were initially conducted in French and later translated into national languages. Various software tools, including Excel and SPSS, were employed for the analysis of the accumulated data.

The outcomes obtained from these data and their analysis enabled us to address the initial research inquiries, validate specific theories, and contribute to the fields of agricultural science and supply chain management.

4. Results

Agri-food supply chain management (AFSCM) is a dynamic and intricate field that covers all aspects of the food system, from production to consumption. It is essential for ensuring the efficient and safe production, processing, distribution, and marketing of food products. In the specific case study of Burkina Faso, the data present a scenario where relying solely on AFSCM may not be suitable for advancing agriculture and the food chain in Burkina Faso due to the production methods employed by farmers. A survey was conducted among 201 stakeholders in Burkina Faso involved in agriculture, logistics, and Supply Chain Management to find out more and for the objectivity of the study. The participants were queried about the specific type of agricultural method they engage in and the results after data analysis were presented in **Figure 1**.

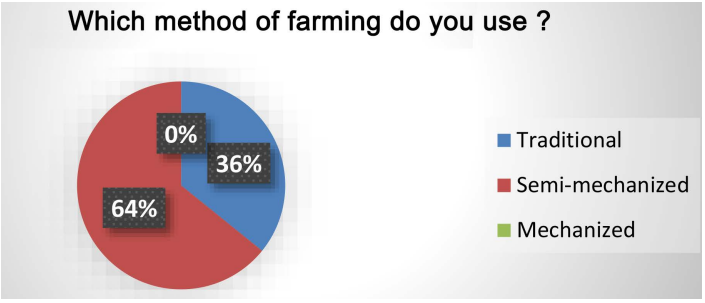

Figure 1. Method of farming.

Upon analyzing the received data, the findings indicated that the majority of farmers employ semi-mechanized and traditional agricultural methods, with the former being the most prevalent. It is noteworthy, however, that none of the sampled farmers exclusively utilize modern agricultural methods. Subsequently, farmers and agronomists were surveyed regarding the agricultural machinery and equipment they employ, as well as their satisfaction with the impact of these machines and equipment on cultivated areas. The results revealed that 74% of respondents felt that the utilized machinery and equipment did not facilitate cultivation in large areas. In contrast, 26% reported that they were able to cultivate extensive areas with the machines and equipment at their disposal (**Figure 2**).

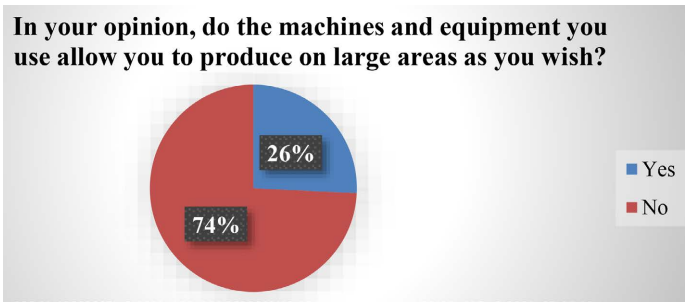

Figure 2. Performance and efficiency of agricultural machines and equipment.

Following these insights, we sought their perspectives on the potential introduction of modern production machines and equipment in Burkinabe agriculture, similar to certain developed countries experiencing remarkable progress through the use of cutting-edge, latest-generation machinery in mechanized agriculture.

This chart presents the perspectives of the stakeholders regarding the introduction of modern agricultural production machines in Burkinabe agriculture (**Figure 3**). It shows that the majority of respondents believe that incorporating modern agricultural production machines will lead to an expansion of cultivable areas, resulting in increased harvests both in terms of quality and quantity, along with a reduction in production costs. They also emphasize that these factors will undoubtedly contribute to the overall advancement of Burkinabe agriculture.

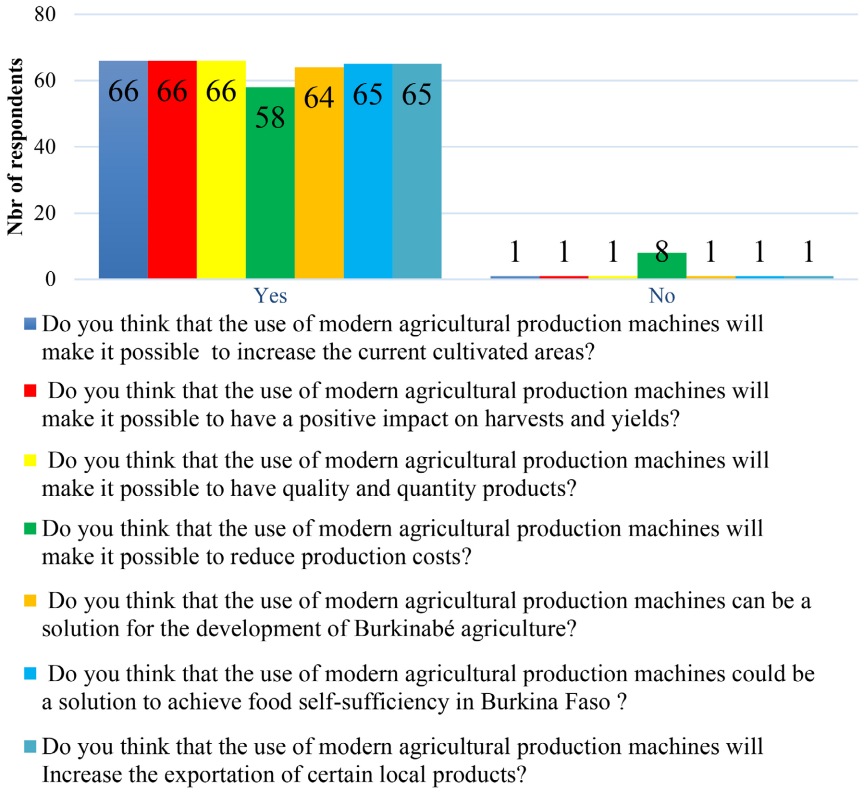

Figure 3. Questions about modern agricultural machines.

Following inquiries related to agricultural production machines and Burkinabe agriculture in a broader context, we delved into questions concerning logistics and agri-food supply chain management. This approach was taken to thoroughly explore and elaborate on the subject. Consequently, the stakeholders were queried about their understanding of logistics and AFSCM.

Of the respondents, consisting of farmers, agronomists, stakeholders in the agricultural sector, and evidently, logisticians and supply chain managers, 68% affirmed having a grasp of logistics and supply chain management (SCM), while 32% from the same sample admitted to lacking knowledge in these areas (**Figure 4**). Consistent with this approach, we delved into questions about Agri-Food Supply Chain Management (AFSCM). The responses indicated that 54% of the participants had some understanding of AFSCM, while 46% were not familiar with it (**Figure 5**).

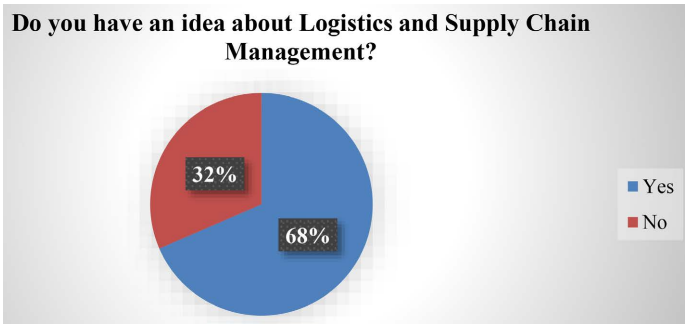

Figure 4. Knowledge of Logistics and AFSCM.

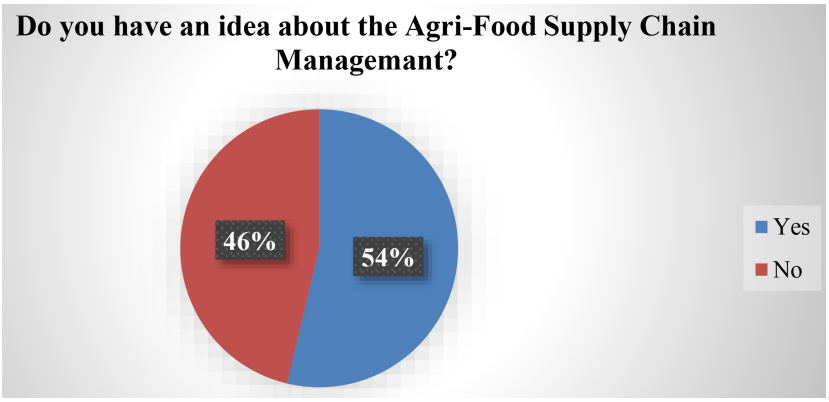

Figure 5. Knowledge of AFSCM.

In line with the methodology of our study, a pivotal aspect was gaining insights into the current state of AFSCM in Burkinabe agriculture, aiming to ascertain its level of development. More than 140 respondents expressed the view that AFSCM is inadequately developed in Burkina Faso, while 38 respondents indicated a lack of knowledge about AFSCM. Conversely, 10 individuals perceived AFSCM as fairly developed, 4 as well developed, and according to one respondent, it is very well developed as shown in Figure 6.

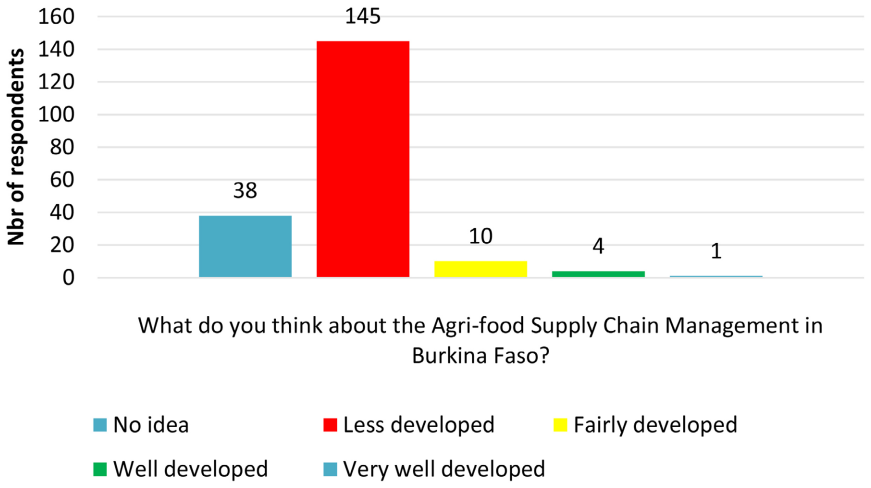

Figure 6. The impact of AFSCM in Burkina Faso.

Following the inquiry into the level of development of Agri-Food Supply Chain Management (AFSCM) in Burkina Faso, we directed our attention to the impact of AFSCM on agriculture and the Burkinabe food chain. The charts (Figure 7 and Figure 8) derived from the analysis of the survey data exhibit patterns closely resembling those observed in the preceding chart.

Specifically, concerning the contribution of AFSCM to Burkinabe agriculture, approximately 120 respondents, consisting of logisticians, supply chain managers, agronomists, and farmers, perceive it as being low in light of current realities on the ground. Another subset of nearly 40 respondents indi-

cated a lack of awareness regarding this contribution. Nevertheless, there exists a group, akin to the findings in the previous chart that assesses the contribution as medium, fairly good, good, and very good, respectively (30; 9; 3; 4) (Figure 7).

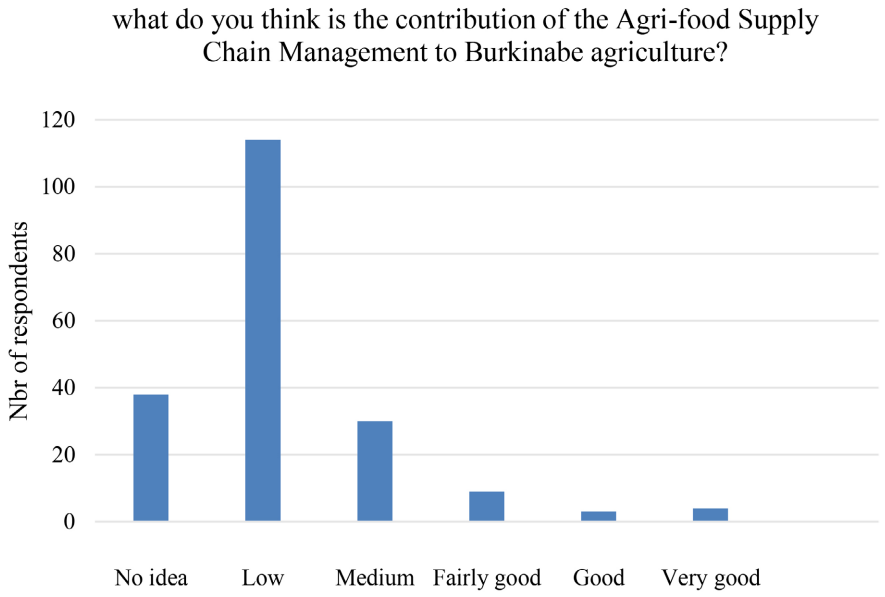

Figure 7. Contribution of AFSCM to Burkinabe agriculture.

Similar trends emerge concerning the contribution of AFSCM in the Burkinabe food chain, where 111 respondents believe that this contribution is low. Another, albeit smaller group of 39 respondents, echoing the previous observations, mentions having no idea regarding the contribution of AFSCM to the Burkinabe food chain. Additionally, 33; 6; 5; 3 respondents find this contribution Medium, fairly good, good, and very good respectively (Figure 8).

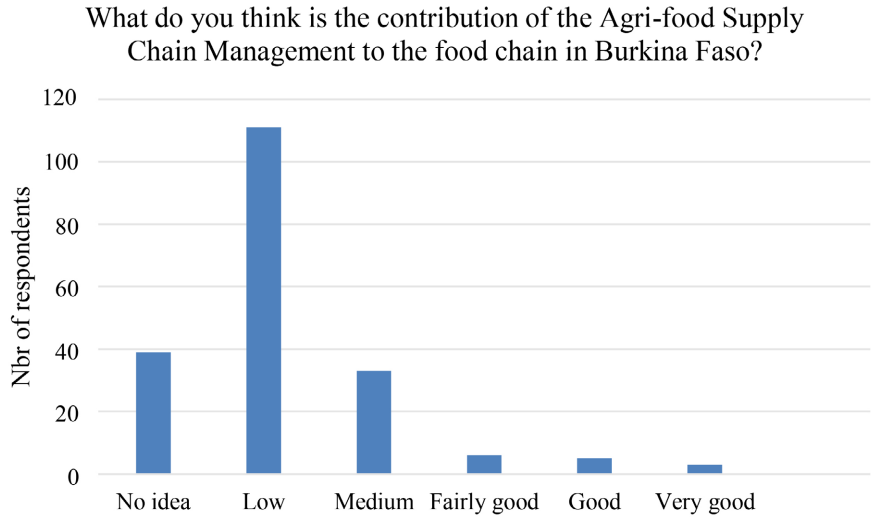

Figure 8. Contribution of AFSCM to the food chain.

Continuing in the same line of inquiry, we delved into the current challenges faced by agricultural producers in Burkina Faso. A certain number of multiple-choice questions were submitted to them, and following the analysis of the data, we noted some of the most commonly encountered by producers. The Conservation of crops post-production was the most mentioned, with a rate of 17% among all points (Problems Encountered) submitted to the respondents, followed by the lack of suitable warehouses or refrigerated containers for preserving crops, representing a rate of 16% of all points, poor road conditions 15%, and communication issues with post-production customers and stakeholders to achieve more efficient distribution of harvests 14%. Crop evacuation problems were also a significant point, accounting for 11% of all problems encountered by the actors in the sample. These challenges proved to be significant issues for agricultural stakeholders in Burkina Faso. Furthermore, although less predominant than the major challenges, other reported problems, while less significant, should not be disregarded, such as high transportation costs, accessibility to carriers, accessibility to inputs and pesticides, and the management of production's machines, with respective rates of 8%, 7%, 7%, and 5%. Figure 9 below provides a comprehensive overview of these points.

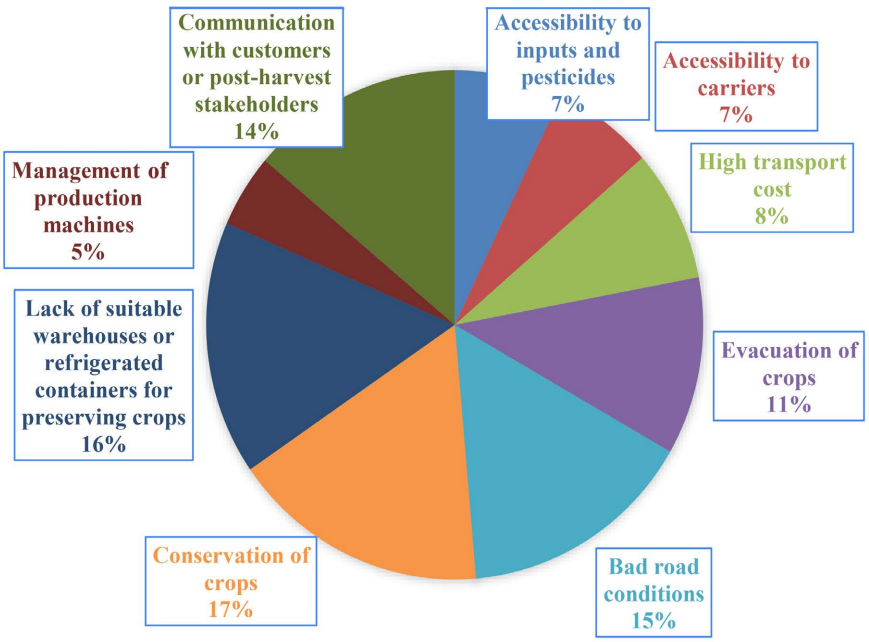

Figure 9. Problems encountered before, during, and after production.

The aforementioned results were derived through the cooperation of diverse respondents spanning all 13 regions of Burkina Faso, representing various sectors related to this research. These findings, coupled with the prior research efforts by other scholars, formed the foundation for the interpretation and discussion section of the study.

5. Discussion

The data of this study were structured in such a way that they are a chronology to better address and develop the subject to respond to the development problem of Burkinabe agriculture. Thus the first step was to ensure the current methods of agricultural production used in Burkina Faso and their effectiveness compared to the current yields of farmers. The second step was to ensure the knowledge of the various actors on the AFSCM and its application in agriculture and the Burkinabe food chain. Thus we have seen through the results that the majority of producers use semi-mechanized and traditional methods of farming and that these methods for the majority do not allow them to cultivate on larger surfaces as they wish because of the limited capacities of the machines used (**Figure 1** and **Figure 2**). Following this, we retained according to the different reactions that the involvement of modern production machines could be a solution to the development of Burkinabe agriculture through the increase of arable land, the improvement in both quantity and quality of crops and especially the reduction of production costs (**Figure 3**). Regarding the AFSCM we found that its application in the agricultural system and the Burkinabe food chain leaves something to be desired because we noted through the results that it is less developed in Burkina Faso and that its application in the Burkinabe agricultural environment is quite weak as well as in the food chain (**Figures 6-8**). This fact does not however remain without impact because through the analyses we retained some problems encountered by Burkinabe farmers that can be solved through the AFSCM.

Certainly, we observed a correlation among our various data points, aligning with the intent of the initial questions. None of the respondents exclusively employs mechanized agriculture; rather, they are involved in traditional and semi-mechanized farming, covering a range of 5 to 30 hectares or more. According to their feedback, these production methods do not allow them to cultivate large areas according to their preferences. Notably, over 90% of respondents unanimously believe that modern agricultural production machines could serve as a solution for the development of Burkinabe agriculture. They anticipate that the adoption of such machinery would increase arable land and positively impact production both in terms of quality and quantity. Consequently, we can affirm that utilizing modern agricultural production machines appears to be a viable solution for the optimal development of Burkinabe agriculture, leading to increased production and profits, thereby addressing our initial question. According to some scholars, the escalating costs of labor stand out as a key factor contributing to the decline in agricultural profitability [9] [11]. The cost of servicing agricultural machinery is usually less than labor costs [9] [12]. The adoption of agricultural machinery by farmers can result in significant reductions in labor expenses [9]. The reduction of production costs through the use of modern agricultural production machines is an important aspect regarding the profitability of farmers as mentioned in the results (**Figure 3**) and the previous find-

ings cited above. Nowadays in Burkina Faso, the surge in mining activities has led to a noticeable migration of labor from agricultural settings to gold mining sites or urban centers. Consequently, the agricultural workforce has become increasingly scarce and costly, posing a significant challenge for producers. Conversely, the adoption of modern agricultural production machines holds the potential to substitute this labor force while concurrently expanding cultivated areas and enhancing the quantity and quality of agricultural products. Furthermore, the utilization of modern machines can contribute to cost reduction due to their heightened efficiency and evolving designs aimed at minimizing energy consumption. Given Burkina Faso's status as a Sahelian country with abundant solar energy, there is an opportunity to develop or embrace hybrid machines (fuel, solar, or gas), to the delight of farmers. This approach would not only decrease production costs but also facilitate large-scale cultivation, benefiting from the powerful and multifunctional attributes of next-generation machines and equipment. Certain researchers have indicated that the catalysts for agricultural growth in Africa are science-based technologies aimed at enhancing productivity [2] [29]. Sustained investment in agricultural innovation systems is crucial for augmenting agricultural productivity and reducing production costs in Africa [1] [2]. The statements of these researchers support our findings.

Notably, our sample includes farmers with varying cultivated hectares, such as 13.8% with more than 30 ha and 53.8%, 12.3%, and 20% for those with areas between 5 - 10 ha, 10 - 20 ha, and 20 - 30 ha, respectively. This challenges us to the further involvement of modern production machines to increase the cultivable areas, with an effect on the quantity and quality of crops.

The question regarding cultivable areas based on the equipment and production machines used by farmers (**Figure 2**), and the question concerning the contribution of modern equipment and machines to the increase in cultivable areas, as well as the quality and quantity of harvests (**Figure 3**), are indeed situations that could be addressed by modern agricultural production machines and equipment. The production capabilities of agricultural machinery can significantly vary, influenced by factors such as crop type, soil conditions, machine configuration, and other parameters. The specific figures may also be contingent on the model and make of the machine.

To overcome the problems faced by Burkinabe farmers, they could effectively adopt modern machines such as modern agricultural tractors capable of performing plowing or seeding work. These types of tractors can cover several hectares per day depending on the type of task. Fertilizer spreaders and sprayers, whose capacity depends on the size of the fertilizer or chemical tank, working width, and speed of movement. These machines can typically treat several hectares per hour. Combine harvesters, whose working capacities may vary depending on the type of crop. They can harvest for example between 20 and 40 hectares of cereal per day, depending on machine size and crop density. Agricultural drones that can be used for crop monitoring or spraying.

The combination of these machines and equipment can significantly trans-

form Burkinabe agriculture, not only by expanding the current cultivated areas but also by increasing both the quantity and quality of the harvests. According to earlier studies, another dimension of agricultural machinery involves enhancing quality and boosting efficiency, primarily manifested through heightened agricultural production and improved product quality. Agricultural machinery, through operations like leveling, land preparation, deep turning, and deep scarification [9] [15], can enhance land quality more effectively than traditional manual and livestock methods, particularly in the conversion of medium- and low-yield fields [9] [16]. The utilization of agricultural machinery can enhance the frequency of multiple cropping on cultivated land, offering the potential for multiple crop cycles within a single year. This, in turn, leads to improved production capacity and increased land output rates. [9] [17]. The findings of these researchers and our own align closely, however.

For the advancement of Burkinabe agriculture through the utilization of modern agricultural production equipment and machines, effective management is crucial for refining the sector. Our analysis revealed that AFSCM is a relatively underdeveloped and less applied form of management in both agriculture and the Burkinabe food chain (**Figures 6-8**), addressing our second question regarding the involvement of AFSCM in these domains. Nevertheless, this has consequences, as we subsequently identified certain issues (**Figure 9**) faced by stakeholders in the Burkinabe agriculture and food chain. These challenges could be addressed through the expertise and adoption of AFSCM. These findings align with the findings of other researchers in the AFSCM, who have also highlighted similar problems. Farmers confront issues such as inadequate availability of financial and human resources, fertilizers, pesticides, raw materials, information sharing, and potential security threats. Additionally, farmers grapple with difficulties in marketing, transportation, receiving a fair share in consumer prices, limited negotiating power, and the lack of infrastructure facilities like refrigerated warehouses [25]. These issues represent an obstacle to the profitability of farmers and food chain actors. Some farmers directly contacted by phone pointed out specific problems related to tomato preservation, expressing: "We sometimes produce, and unfortunately, we witness powerless the rotting of our crops due to the lack of communication with buyers or transporters and The lack of suitable means for preserving our harvests" (Sanou Ivette, Tomato Producer in "la region des Hauts Bassins").

To address these issues, AFSCM would be an effective solution in the sense that this method could track the agricultural production chain from the implementation of inputs and seeds to production, through the use and management of modern agricultural production equipment and machines. AFSCM could also efficiently manage harvests through machines such as combine harvesters to optimize harvesting operations, save time, and adequately reduce farmers' reliance on constant labor for harvests. All these elements combined will undoubtedly enable the development of the Burkinabe agriculture and food chain because the chain will be monitored and coordinated before production, from farmers to

industrial processing units or final consumers. Below, we have an illustration of our proposed Agri-food Supply Chain (Figure 10).

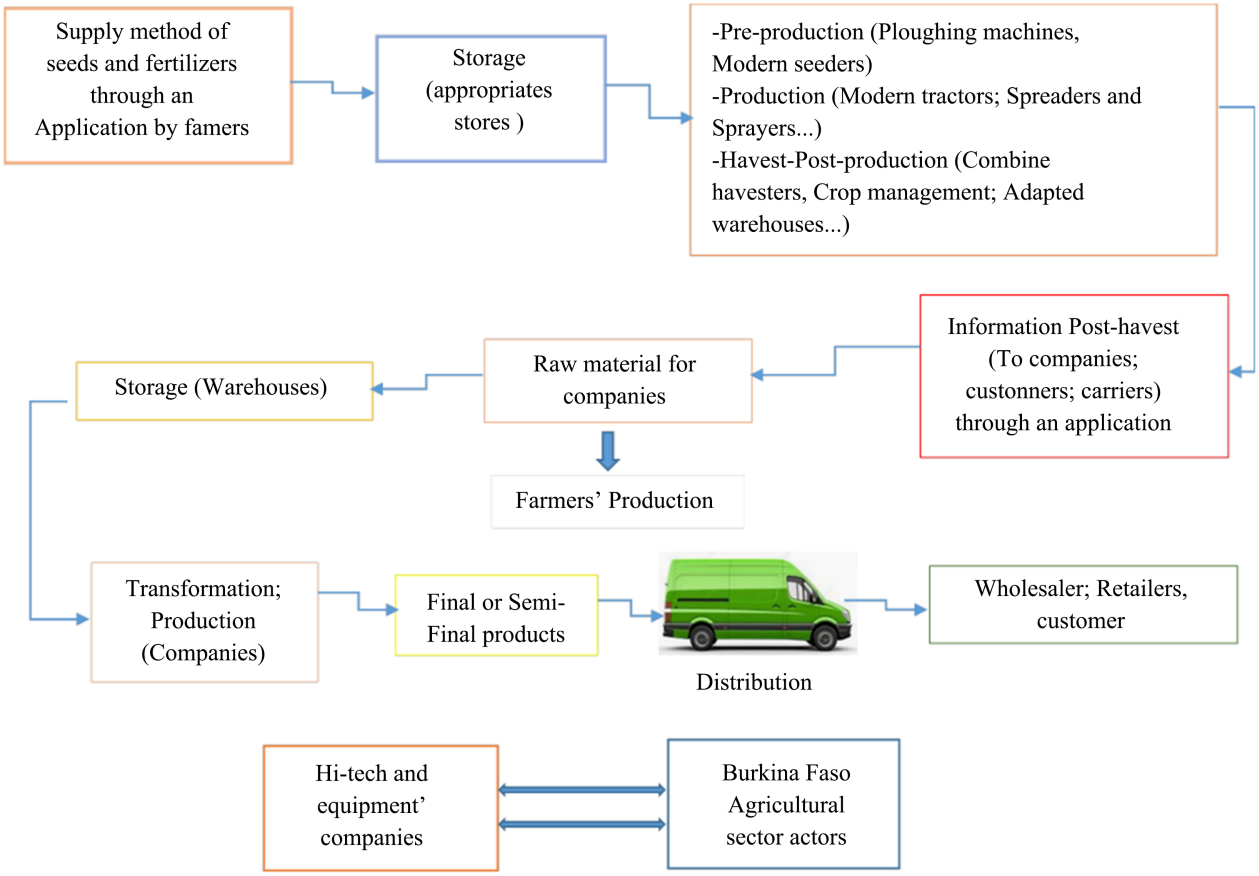

Figure 10. Proposed AFSC model

As a solution to harvest management and communication issues among stakeholders, a communication and information system (Application) could be implemented to facilitate communication between farmers and post-harvest food chain participants. This tool would help catalog harvests based on their locations across the territory and send notifications of available freight to transporters also present on the platform. This would significantly reduce transportation costs as these transporters could group products based on the localization system. Moreover, it would allow road transporters to spend less time searching for collection points and remain consistently active.

Additionally, specialized warehouses or refrigerated containers would be necessary for the storage of harvests according to their types. This approach would serve as a solution for proper harvest preservation. Grouping warehouses could be built in each provincial capital to directly purchase products from farmers. This would ease their task regarding the sale of harvests and enable transporters to find grouped and packaged freight on-site ready for transport. However, efforts will need to be made by the Burkinabe government in the rehabilitation of

degraded or deteriorating roads. Well-maintained roads will lead to a substantial decrease in both fuel consumption and frequent breakdowns for freight vehicles. Consequently, this will contribute to lowering the overall transportation costs, resulting in the availability of more affordable goods in the market. According to [30], The growth of agriculture in Africa relies significantly on institutional and infrastructure advancements. Infrastructure development plays a vital role in lowering input costs for farmers and expanding opportunities for selling their produce by establishing connections between farmers in rural areas and market centers [1] [2].

The combination of Modern Agricultural Machinery and AFSCM is identified as one of the key factors that can significantly contribute to the development of Burkinabe agriculture according to this study. The data received from the collection confirms this, as it has allowed us to address our initial questions and has provided valuable insights into the development of Burkinabe agriculture and the food chain. However, it should be noted some difficulties were encountered during this study such as the reluctance of some people to the questionnaires, and data collection, especially from farmers in remote areas of Burkina where internet access is not available or unstable. This affected the global sample which was 201 respondents. Nevertheless, the results are valid because they allowed us to answer the initial questions, verify existing theories, and make suggestions and recommendations to solve problems related to the development of agriculture and the Burkinabe food chain. This study could become the basis for a more general theory and extend its scope to Sub-Saharan African countries, provided that we can further expand the sample size. This could be the subject of future and more in-depth research to introduce tools such as analytical software powered by artificial intelligence (AI). These tools, leveraging information from data provided by intelligent sensors and IoT (Internet of Things) satellites, could make predictions for farmers [31]. Farmers could make decisions, for example, regarding which types of crops to cultivate, soil moisture, irrigation, fertilization, harvests, etc. Additionally, based on the information provided by these tools, farmers could make decisions to protect their crops from natural phenomena or disasters. Regarding storage warehouses, these tools could help monitor storage conditions to prevent potential contamination or spoilage.

6. Conclusions

This study examines the contribution of modern agricultural production machinery and agri-food supply chain management in promoting effective agricultural development in Africa, using Burkina Faso as a case study. Following the analysis of our results, we retain that exclusively mechanical agriculture is a technique that is not applied by Burkinabe farmers, who are more inked on traditional and semi-mechanized agriculture which, according to them, do not allow them to go beyond their imaginations. We also noted that AFSCM is a type of management that is less used in agriculture and the Burkinabe food chain, yet

could be a solution to the countless problems faced by actors in these environments.

The integration of modern machinery not only addresses the challenges of traditional farming methods by increasing arable land, the quantity, and quality of products but also catalyzes economic growth and poverty alleviation, especially in a country like Burkina Faso, where agriculture is the backbone of the economy. In addition, the study highlights the essential role of Agri-Food Supply Chain Management (AFSCM) in optimizing the flow of agricultural products from the place of production to the final consumer. The analysis of the case of Burkina Faso reveals that an efficient supply chain is crucial to minimize post-harvest losses, set up a good communication system between actors, ensure fair incomes for farmers, increase the profit of the chain's stakeholders, and meet the demands of a growing population. The implementation of robust supply chain strategies, supported by technological innovations and effective management practices, can contribute significantly to the development of agriculture and the Burkinabe food chain with the direct effect of ensuring food security and strengthening the overall resilience of the agricultural sector to external shocks and market fluctuations.

However, the successful implementation of modern agricultural machinery and agri-food supply chain management in Burkina Faso requires a holistic approach. Decision-makers, stakeholders, and international partners must work together to provide the necessary infrastructure, training, and financial support. In addition, it is necessary to continue research while going beyond the number of people used by this study to set up an even more general theory and also combine smart technologies such as AI and IOT for a more advanced agriculture and food chain. This will allow technologies and strategies to be tailored to the specific needs and challenges facing African countries. In essence, the study highlights the importance of a comprehensive and responsive approach to harness the benefits of modern agricultural practices for sustainable and inclusive agricultural development in Burkina Faso and in Africa as a whole.

Conflicts of Interest

The authors declare no conflicts of interest.

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