Agrifood Supply Chain Traceability: A Systematic Literature Review

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***Abstract*— This paper investigates the knowledge gaps in the published research on agri-food supply chain traceability (AFSC), identifies the main unexplored issues and potential research gaps, and sets the research agenda for future researchers. A systematic literature review of the quality work/papers on AFSC traceability was done for the period (2008-2020) using a PRISMA flow diagram. The systematic literature review results have provided insight into the present literature and set future research directions related to agri-food supply chain traceability-related to re-search. The study reveals several critical issues related to all the stakeholders; it has furthered understanding of drivers and challenges and Food Traceability System contributions from a practical perspective. This paper has used only quality research work of 12 years only as per set inclusion and exclusion criteria which is the study's main limitation. It identifies significant knowledge gaps and defines directions for future research. This work has explored the current state of the regulations and potential technologies to help effective decision-making practices that managers can use in AFSCs.This study has presented an idiosyncratic set of research domains for further investigation in the area.**

***Keywords*—** Supply Chain Management, Agri-food, Agrifood Supply Chain, Food Traceability, Sustainability

1. Introduction

Consumer interest has increased in recent years, especially in food products, because of their direct health consequences [1]. Consumers now consider the food chain's transparency to develop their judgment on the food's quality and safety [2-4]. In the agri-food supply chain (AFSC), to gain consumer confidence, there is a need to develop forward and backward integrated traces from the farm to the consumer and vice versa [5-7]. It was emphasized that traceability has become very important, especially for safety-sensitive fields like food and pharmaceuticals [8]. The implications of previous food-related health crises, such as Bovine Spongiform Encephalitis (BSE), dioxin contamination, swine flu, etc., have also generated interest from governmental and non-governmental bodies [9, 10]. Thus, the European Union launched the targeted program in 2000 called Food Trace to restrict such incidents in the future. The final report concluded to trace potential contamination risks to source and ensure swift withdrawal strategies before reaching the markets [11].

AFSC was confronted with an unending demand for improved food safety and quality, efficient risk management, and rapid recovery by actors along the "farm-to-fork" mile [12]. Today`s consumers emphasize food safety and have high expectations of SC for achieving it, as concluded by recent research [8]. The AFSC is distinguished from other supply chains (SCs) by its quality and safety requirements and weather effects [13]. The perishability (short-shelf-life) and seasonal variability of demand and price are other unique characteristics of AFSCs, contributing to its complexity [9, 10]. To address the growing concerns over AFSC, traceability has gained tremendous interest in recent years [14]. To define traceability in the context of AFSCs, the EU Law refers to the ability to follow the history of a food product or components of that food product through its supply chain (SC) stages of production, processing, and distribution [11]. For instance, the latest research, for example, Casino et al. [15], has also emphasized implementing a regulatory regime in achieving such standards. Food traceability encompasses both tracings (backward traceability) and tracking (forward traceability) [16]. Three critical components reflected in traceability definitions are as follow: backward follow-up of products till the primary source of input materials (tracing), forward follow-up of products till the final consumer (tracking), and the associated product history information recorded with the movement in SC [17]. Saetta and Caldarelli [18] emphasized that technological innovations can improve food supply chain traceability in all steps,

including production, processing and logistics management.

2. Literature Review

Understanding traceability in this context requires consideration of issues from a theoretical and practical point of view. As a first step, this study aims to summarize existing literature available on AFSC traceability and identify the main issues, potential research gaps, and derive some recommendations for future research. Furthermore, this study also aims to identify and explore the current state of regulations and the possible technologies that can facilitate traceability in AFSCs.

Recently, few systematic literature reviews were conducted on different aspects of foods. For instance, [19] conducted a systematic literature review of qualitative papers on Halal foods' consumer aspects and Irfan Ishaq [20] conducted a meta-analysis of quantitative studies based on TPB (Theory of planned behaviour) on halal foods. However, few systematic literature reviews have also studied the supply chain aspect of various other kinds of foods. For instance, Secinaro and Calandra [21] have categorized Five main clusters. Similarly, Ab Talib, Syazwan [22] worked on the halal supply chain's critical success factors. Beske, Philip [23] also conducted a systematic literature review on sustainable supply chain management in the food industry. They found that sustainability practices and dynamic capabilities in the supply chain are used to enhance traceability and tracking and fulfil customer demands. In a recent review, Patelli and Mandrioli [24] has emphasized adopting BlockChain technology with specific modalities in specific kind of food is. Demestichas, Konstantinos [25] also reviewed all studies on blockchain technology and its utility, specifically for the traceability of the food sector. Kamble, Sachin [26] identified traceability as the most critical enabler for the food sector. Feng, Jianying [17] reviewed the characteristics and enablers of blockchain technology in the food sector. The above papers have focused only on one dimension rather this paper developed a holistic review of all the available studies on food traceability.

This presented paper is structured as follows. The next section presents the methodology followed in conducting this systematic literature review (SLR). The third section presents the results of the analysis and classification of the selected literature, and through critical thinking, highlights the key findings, research gaps, and potential implications. Finally, this research paper presents the results and proposes future research directions.

3. Research Methodology

The SLR method is an evidence-based approach that identifies, selects, and analyses the most relevant secondary data to provide a deep understanding of what is already known, highlight gaps, and suggest future research paths [27, 28].This method's fundamental principles (i.e. transparency, inclusivity, and an explanatory and heuristic nature) allow a more objective overview of search results and reduce bias and error [29]. The SLR synthesizes evidence from existing studies, creating new knowledge and important as conducting further research [28]. Our methodology is based upon the five steps adapted from [28, 30]. Figure 1 represents the five steps undertaken in this research study.

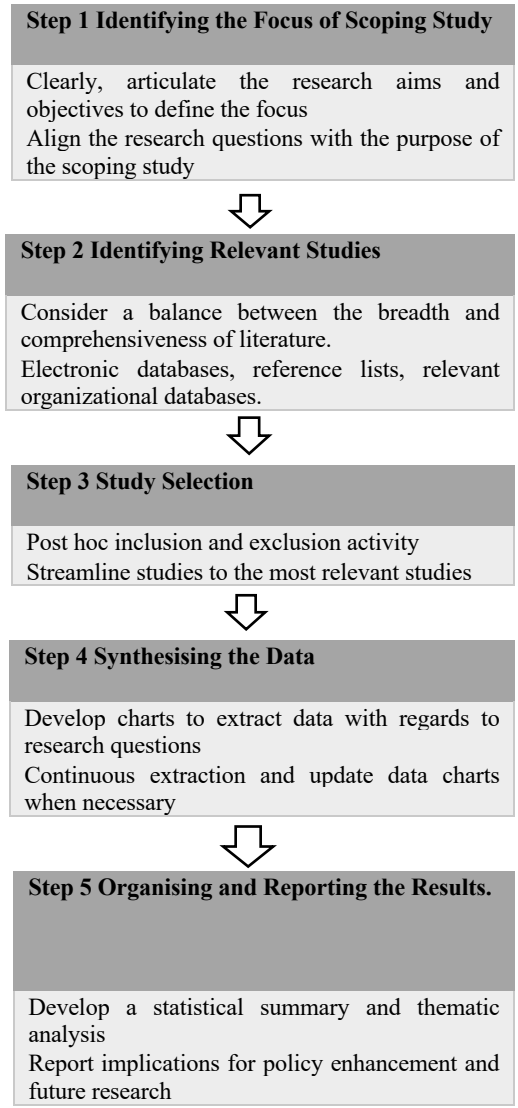

Figure 1: Steps of the SLR Process

The presented steps are explored in more detail in the following section of the research study.

Step 1: Scoping Study

A scoping study has become a necessary part of a systematic literature review (SLR) to examine the current extent, range, and nature of research activity [30, 31].The scoping study is also necessary to determine the essence of the research topic, summarise and disseminate research findings, identify the research gaps in the current literature, and address the lack of thoroughness of traditional literature reviews [27]. After the scoping study, in a systematic literature review, the next step is to develop a clear focus and, therefore, rigorously address clearly defined research questions, which have to be well specified, informative, and unambiguously formulated [32, 33].

The following review questions were applied to ensure focused SLR and to guide the scope of this study;

RQ1. What drives the interest of stakeholders in AFSC traceability?

RQ2. What are the drivers and challenges to the implementation of AFSC traceability?

RQ3. How does traceability contribute to the long-term sustainability of the environment (planet), social (people), and economic (profit)?

RQ4. Are regulations fundamental to the success of AFSC traceability implementation?

RQ5. What is the state of technologies and the possible improvements necessary in AFSC traceability?

Step2: Identifying Relevant Studies:

A search process was followed to identify relevant research publications on various databases includes ABI/Inform, Springer Link, Emerald, ProQuest, Science Direct, John Wiley and Sons, and Taylor and Francis databases. **Figure 2** below distributes the articles based on the keywords used.

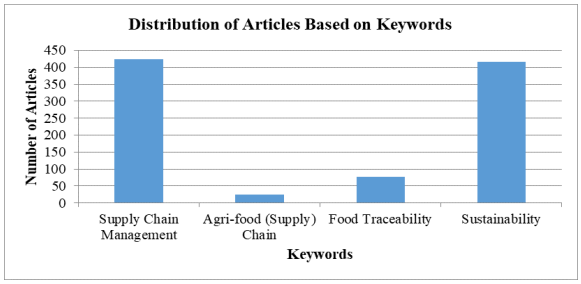

Figure 2: Distribution of Initial Studies Generated

Step 3: Study Selection

The 941 publications were found in Step 2, which represents a broad study area, and there is a high likelihood of accessing many irrelevant studies [31]. Hence, post hoc inclusion and exclusion criteria were utilized to eliminate unrelated studies [34, 35]. This stage screened 730 relevant publications, including journal papers, conference reports, book chapters, and Ph.D. theses.

Although a scoping study does not assess the quality of evidence [31]. It can yield a broad overview of the available literature, forming the second stage of the literature review. The approach to literature search for the SLR was to derive keywords from the focus of the scoping study and combine them using the Boolean operators [36] Moreover, while some keywords choose from the extant literature, the authors also conducted a brainstorming session to identify other keywords [37]. The selection was subsequently discussed with other research colleagues to validate the keywords, enhance quality and create a more accurate and focused literature review. The keyword combinations are targeted to answer the specified research questions illustrated below in figure 3.

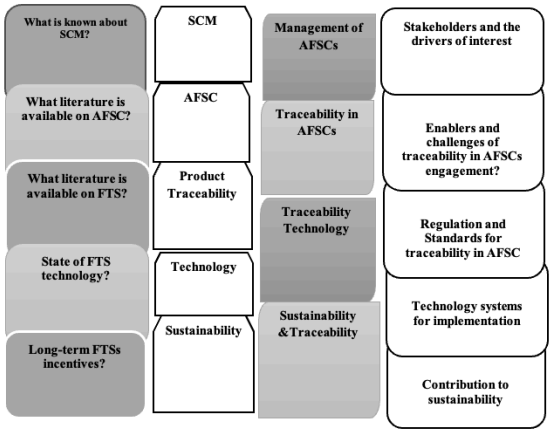

Figure 3: Keyword Generation and Combination

Step 4: Synthesizing the data:

This research study has followed a systematic, replicable, and transparent article selection process. The search result was further with a timeline (2008 – 2020) which resulted in selecting 211 articles. The 211 publications were sieved through a four-level screening questionnaire (SQ), as detailed in Table 1, which yielded 73 articles.

Table 1. Screening Questionnaire

No.	Question	Reply	Remark
SQ1	Does the article relate to supply chain management?	YES / NO	If YES, continue to SQ2; if NO, exclude the article.
SQ2	Does the article relate to AFSC?	YES / NO	If YES, continue to SQ3; if NO, exclude the article.
SQ3	Does the article relate to traceability?	YES / NO	If YES, continue to SQ4; if NO, exclude the article.
SQ4a	Does the article relate to either technology, regulation, or sustainability?	YES / NO	If YES, select article; if NO, continue to SQ4b
SQ4b	Does the article unearth the enablers and challenges or the future drive for traceability in AFSCs?	YES / NO	If YES, select article; if NO, exclude the article

Step 5: Organizing and Reporting the results

According to the PRISMA statement given by Moher, David [38] we restricted our research to peer review literature to achieve better quality output in the review process. After this screening, the 73 articles qualified for inclusion in this review research study. A study assessment was ranked hierarchically based on their relevance; the top 49 articles were selected for full analysis and synthesis for this study. **Figure 4** shows a PRISMA flow diagram explained the details of articles.

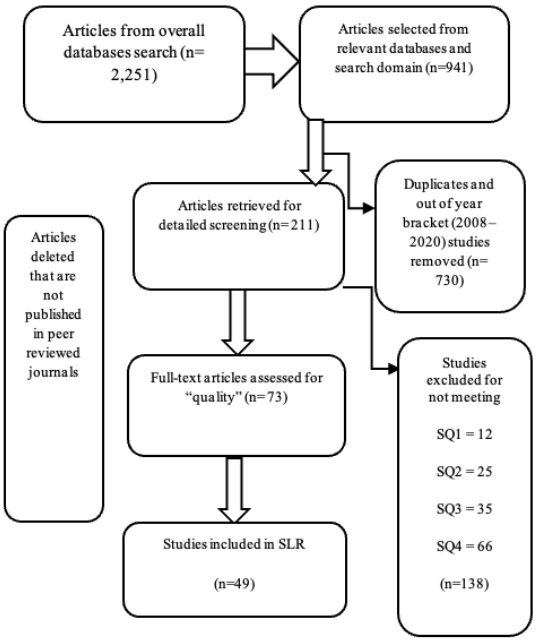

Figure 4 PRISMA Flow Diagram

4. Results

According to the publication type, selected articles were categorized - journal articles, book chapters, or conference papers. The pie chart distribution shown in Figure 5 shows a 76% inclusion of journal articles, 18% of conference papers, and 6% of book chapters. Additionally, the classification based on publications per year shown in figure 6.

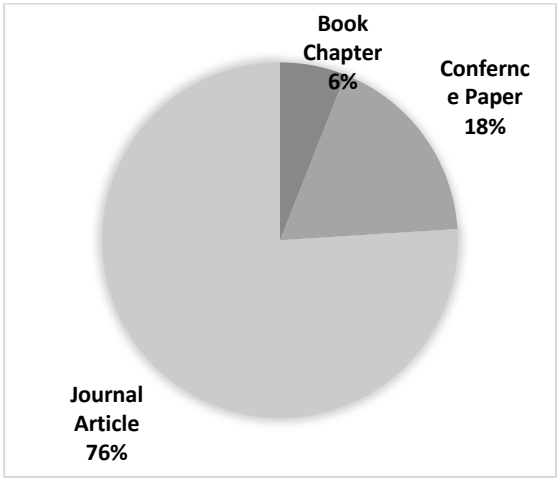

Figure 5 Distribution of Publications Types

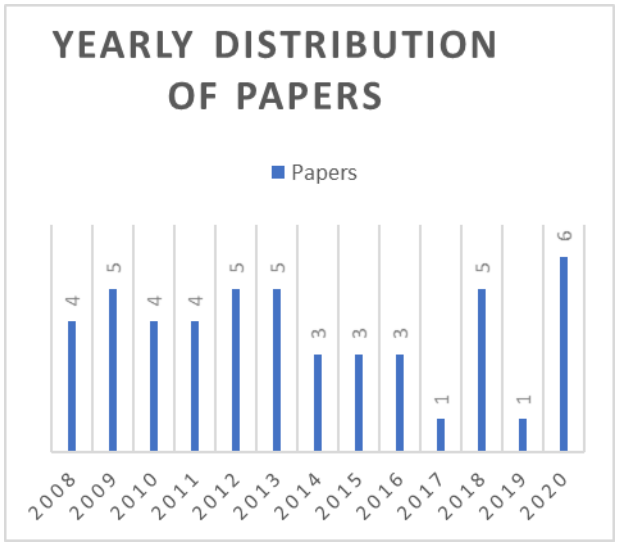

Figure 6 Yearly Distribution of Publications

The selected papers were classified according to the agri-food branch; they focused on crop food, animal food (meat), and fish. The results also revealed that some articles addressed general issues in the AFSC with no specific focus on a branch. Some studies focused on a comparative study of multiple agri-food sectors. The results of this classification are summarized below in Figure 7

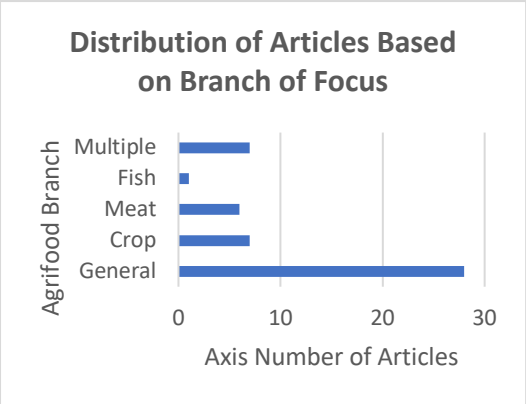

Figure 7: Distribution of Articles Based on Agri-food Branch of Focus

As the majority (58%) of the studies focused on the general AFSC, and seven papers (14%) addressed issues in multiple AFSC sectors. The other articles focused on the crop (7 studies, 14%), animal (6 studies, 12%), and fish (1 study, 2.38%). Fish accounted for the lowest number of papers because of its relatively low popularity and limited SCM issues.

4.1 Journal-wise Classification of Publications

This classification presents the number of publications that were selected from the various journals available. This distribution of publications is shown below in table 2:

Table 2. Number of Publications in Different Journals.

Journal	**Number of Papers**
Br Food J	8
Food Control	5
Ethical Traceability and Communicating Food	3
Food Policy	2
Computers and Electronics in Agriculture	2
Industrial Management and Data Systems	2
International Marketing Review	1
Tropical Animal Health and Production	1
European Journal of Operational Research	1
European Journal of Law and Economics	1
Appetite	1
Journal of Rural Studies	1
Journal of Production Economics	1
Supply Chain Management: An International Journal	1
Global Perspective for Competitive Enterprise, Economy and Ecology	1
International Journal of Logistics Management	1
Journal of Systems and Information Technology	1
International Journal of Services Operations and Informatics	1
International Conference on Sensing Technology	1
Conference on Industrial Electronics and Applications	1
International Conference on Advanced Communication Technology	1
International Conference on Communication Software and Networks	1
European Workshop on RFID Systems and Technologies	1
International Conference on Intelligent Computational Technology and Automation	1
International Conference on Service Systems and Service Management	1
IoT Vertical and Topical Summit on Agriculture	1
If-Papers online	1
Applied Sciences	1
Journal of cleaner production	1
International Journal of Information Management	1
Journal of Food Science	1
Procedia Manufacturing	1
Sensors	1

4.2 Classification Based on Issues of Traceability

The papers were further categorized based on the traceability issues they covered. For this study, the focus was on the following issues;

- Traceability technology
- Contribution to quality and safety (Q & S)
- Contribution to sustainability
- Drivers and challenges (D & C)
- Rules and Regulations that ensure traceability
- Stakeholders of traceability implementation

Figure 8 below shows a distribution of the 49 publications and the research question (traceability issues) that they addressed:

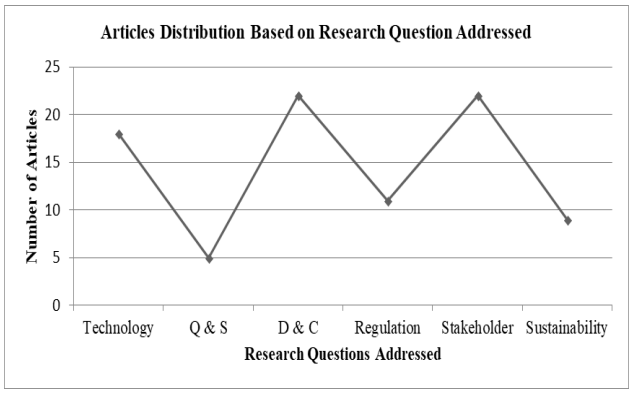

Figure 8: Distribution of Articles Based on Research Questions Addressed

It is worthy to note that some papers addressed multiple issues, as depicted in the figure above. The benefits of a concept can only be effectively measured when the foundation of the idea is efficiently constructed, hence the low concentration of research in those areas until recently when sustainability demands have increased. Issues with fewer publications do not necessarily mean they are less critical but may indicate the criticality of the concentrated matters.

4.3 RQ1 Stakeholder Involvement

A primary research objective was to determine the interest groups in AFSC traceability and the motivation for their interest. All those papers which have discussed the main research groups regarding AFSC traceability in any context were analysed, and these stakeholders are broadly categorized.

4.3.1 Consumers

The consumer is a significant stakeholder in the AFSC – as for every supply, there should be a demand. The consumer's feedback also serves as the primary input into an improvement on the SC, and a firm's competitiveness depends on how well they satisfy their customers.

To address consumers' health concerns, clearly stating allergies and possible side effects establish consumer confidence in the product's health and environmental impact [39, 40] is a significant driver for consumer interest in food traceability issues. Household demographics are a significant driver of consumer interest [41]. The age distribution, religion, income levels, and household' size are vital determinants of an individual's interest in traceability information [42]. The final factor of purchase decisions is income; hence, homes with lower incomes may not show much motivation to demand traceability information than a higher-income family.

4.3.2 Farmers/ Producers

In the AFSC, the farmer/ producer's role is core to the traceability system's success. Farmers require traceability systems to ascertain the fulfilment or otherwise of consumer demands and the end impact of the product on the environment. Consumer feedback is necessary for product quality improvement, product differentiation, and improved market competitiveness. Producers are burdened with the consumer demands for traceability through the retailers/ wholesalers [43]. Hence, to win orders from large retailers such as ASDA, Tesco, Morrisons, etc., producers must meet these traceability system demands. The regulatory and legislative instruments in a country also drive the producer's interest in AFSC traceability. Producers are bound to comply with regulations and social expectations, creating a traceable production system as evidence of their compliance [44].

4.3.3 Agri-food Processors

Agri-food processors are motivated by competition in the agri-food processing sector since farmers can easily opt for a competitor that practices traceability. Agrifood processors also have a brand image to protect, hence maintaining consumer confidence; they need to meet consumers' traceability demands [45]. A traceability system also helps manage inventory more efficiently and monitors its entirety; hence, fraudulent intermediaries engaged in mislabelling along the SC can be tracked [46] .

4.3.4 Distributors (Wholesalers, Retailers, 3PLs)

Distributors bridge the gap between supply and demand. Distributorship is usually met with stiffer competition because of the accessibility of many substitutes within a geographical area. Therefore, they are motivated to play a role in implementing traceability because of their interest in protecting their private labels and the desire for a swift information exchange process with their downstream and upstream supply chain [46]. Distributors are motivated to invest in a traceability system to meet other stakeholders' demands and solidify brand image [43].

A) Governmental Bodies/ Agencies

Governmental agencies are responsible for ensuring their population's betterment; hence, they regulate policies focused on economic, social, and environmental sustainability. To enact targeted regulations, these governmental agencies require up-to-date information from SC. Therefore, FTS gives information on the ecological impact of an AFSC to help enact and enforce regulations to maintain sustainability standards in the food products [47].

4.3.5 Network Partners

Traceability implementation requires a consensus on all SC partners to develop an interoperable system or integrated system. Traceability systems are needed to trace internal and external risks in the AFSC and develop effective solutions. Traceability minimizes cost by facilitating the exchange of knowledge and information, and it serves as a motivation for attaining consensus in the practice of a traceability system [48].

4.4 RQ2 Drivers and Challenges

This study's primary research objective was to uncover the drivers and challenges as identified by previous literature. The drivers and main challenges are considered the main elements that help attain traceability or implement it properly. Thus, the perspective of these elements was dug out from the paper and presented here. The identified drivers included;

4.4.1 National Policy/ Standard

An enforceable policy details all the AFSC partners' requirements and serves as a mandatory framework that stipulates standards for food products to be met by actors. When there is a policy backing traceability, the opportunistic behaviours of AFSC partners eliminated [49].They added that, in the absence of an accepted policy or standard, voluntary traceability usually leads to the proliferation of various traceability rules leading to an ineffective FTS.

4.4.2 Technology

The availability, cost, and complexity of the devices and systems to an enormous extent influence the adoption of traceability by AFSC partners. When sophisticated equipment was used, it was expensive and difficult to obtain; therefore, few companies have implemented FTS. However, the advent of more straightforward and cheaper technologies and systems has facilitated the AFSC tracking to integrate information into SCs through competitive advantage.

4.4.3 Monetary and Non-Monetary Incentives

Voluntary traceability is usually driven by better SC efficiency; benefits, such as the monetary or non-monetary impulse needed to perform the FTS [49].The non-monetary incentives include the increased brand reputation among consumers through consistent delivery of quality and safe food [37, 50]. The improved production and labor efficiency and increased profits constitute the monetary incentives [50].

4.4.4 SC Dependence, Trust, and Commitment

SC effectiveness relies on the collaborative effort of all SC partners towards a mutual goal. Traceability involves sharing information (product, internal process, etc.) with other SC partners, which may be very restrictive considering the probability of patented production methods leaked to competitors. Firms that are more dependent on the AFSC are more willing to share information, and dependence is a qualifier and develops trust and relationship commitment [51]. Farmers (producers) are more likely to share information among dependable, trustworthy, and committed partners than other SC. In AFSCs, the implementation of traceability inhibited by the following challenges;

4.4.5 High Set-up Cost

The structuring and implementation of FTS are expensive, and its execution is a complicated task. According to Manos and Manikas [52]. The systems and devices required to set up an FTS are costly, resulting in low profits, limiting the number of agri-food firms capable of meeting this requirement. According to Ringsberg [46], sharing initial costs and benefits among AFSC partners is usually met with resistance. Moreover, in circumstances where firms agree to bear the cost of implementation, much of this cost is transferred to the consumer through higher prices.

4.4.6 Regulatory Issues

Ineffective enforcement of regulations tends to hinder FTS implementation. Vague regulations create disparities in the actors' various traceability systems, eliminating the interoperability requirement of FTS. Manos, Basil [52] noted that the EU Legislation did not specify the type of FTSs a company should adopt and further gives countries the right to enact their standards; hence there is difficulty reaching a consensus among SC partners. Which also limits global trade when the standards of different countries are involved.

4.4.7 Supply Chain Coordination Issues

The internal traceability systems of SC partners must lend themselves to combined into an integrated system. Manos, Basil [52] concluded that SC integration was a requirement for an efficient FTS hence the need to ensure continuous information sharing. In the implementation of an FTS, there are usually no formal contracts between SC partners; therefore, there is the likelihood of conflict of interest since every firm will instead be focused on achieving their internal targets ahead of the AFSC [48].

4.4.8 Technology Issues

Technological challenges such as complexity, incompatibility with other devices and systems, high set-up cost, etc., have become significant challenges that firms face in implementing FTSs. The benefits of FTS can only fully achieve when advanced technologies are adopted; however, cost limits the abilities of firms to use these technologies despite the inefficiencies of the outmoded technologies.

4.4.9 Lack of a Unified Identification System

The absence of a standard system in FTS means most SC actors implement traceability based on their internal systems, hence challenging to be linked together with other systems. Accordingly, the lack of a unified identification system blocks information flow within the chain and becomes unrewarding to implement an FTS.

4.5 RQ3 Contributions of AFSC Traceability

The contributions of FTSs are either short-term or long-term and qualitatively perceived or quantitatively estimated [53].The benefits identified in the studies can be classified into five major groups as discussed below;

4.5.1 Improved food safety and quality

The modern consumer desires the assurance of the safety and quality of food. Food scares reduced consumer trust and confidence; however, food crisis management can reaffirm trust and confidence. An efficient FTS helps minimize the distribution of unsafe food, facilitates quick recalls to limit the extent of damage; hence, consumer satisfaction is maximal in a traceable AFSC.

4.5.2 Competitive Advantage

The consistent fulfilment of consumer demands brings a competitive advantage to AFSC actors. The benefits of an efficient FTS, such as enabling swift responses to food scares, a clear understanding of the firm's logistics system, and product quality improvement based on consumer feedback, are vital for a competitive industry such as the AFSC.

4.5.3 Improved AFSC performance

The practice of an FTS reduces costs of logistics activities facilitates timely information sharing among AFSC partners, ensures the visibility of partners activities, enhances AFSC integration to differentiate food products and enables the efficient management of firms' resources [54]. This management improvement encourages increased visibility and cooperation among partners to develop partners' technical and economic capabilities.

4.5.4 Technological and Scientific Improvement

Implementing an effective FTS requires an equally capable technology. Hence the continuous demands in traceability such as the data to trace (volume, weight, dynamism, etc.) and the accuracy and reliability of such data require continuous improvement in technology and scientific solution.

4.5.5 Agricultural Sustainability

As traceability continuously increases food safety and quality, it improves the production and distribution system and brings about enormous benefits in the long run. These sustainability benefits can be classified as either economic (profit), social (people), or environmental (planet). Campbell [36] also explains hierarchical data architecture for sustainable food supply chain management.

1) 4.5.6 Economic Benefits (Profit)

The improved AFSC reduces wastes in the production system, thus reducing cost. It is costly to establish an FTS; however, the long-term rewards are gratifying, and firms that practice FTS can recoup profits to balance off the initial cost of set up. Food losses due to quality problems are very costly, and executing food recalls are expensive. Still, with FTS, the cost can be reduced since the exact product can be easily traced to be recalled averting further casualties and increased damage charges.

4.5.7 Social Benefits (People)

Traceability information gives details about the product's composition; hence, consumers can avoid food with inputs they are allergic to. This benefit helps maintain the health standards of the society, and epidemics resulting from food crises can be easily traced and treated.

4.5.8 Environmental Benefits (Planet)

FTS gives information on production capacities; hence, depleting food products like fish and other seafood can be monitored and avoided. The chemicals (pesticides, vaccines, etc.) used in the food production system can also be traced to monitor their impact on the environment [45].FTS captures the disposal and recycling of agri-food wastes, which may be dangerous to the environment.

4.6 RQ4 State of Regulations in FTS

Regulations help monitor the practice of traceability, detailing the rights and responsibilities of all partners. The European Union has made significant progress in the regulatory and legislative instruments to streamline agri-food traceability implementation. These regulations are General Food Law (GFL/178/2002/EC), GMO Traceability Regulation 1830/2003, Fisheries EC 2065/2001, and Packaging Materials EC 1935/2004. Other regulations identified by the authors include the UK's 1990 Safety Food Act, which was incorporated in the EU Food Law in 2002, and the USA's Food and Safety Modernization Act (FSMA) and Bioterrorism Act. The FSMA stipulates guidelines for ensuring food safety and regulates the recall of products when necessary [46]; industrial and International Standards such as Cortex, ISO, etc., also supports the regulation of food traceability. Hence law and legislative instruments play an essential role in implementing

traceability; however, Mattevi, Mattia [55] noted relatively low regulatory compliance. Despite the absence of strict enforcement of these regulations globally, most SC actors practice voluntary traceability motivated by a cost-benefit analysis of its implementation. However, Aung, Myo [56] argued that AFSC traceability's success depends on the availability of defined standards that facilitate interoperability. This means that regulations and international standards are requisite for the successful implementation of AFSC traceability. However, to achieve optimum benefits from the enforcement of traceability regulations, it is essential to look beyond legislation and invest in the enforcement, education, and sensitization of AFSC actors of interoperable traceability systems globally; thus, a motivational driver for voluntary traceability.

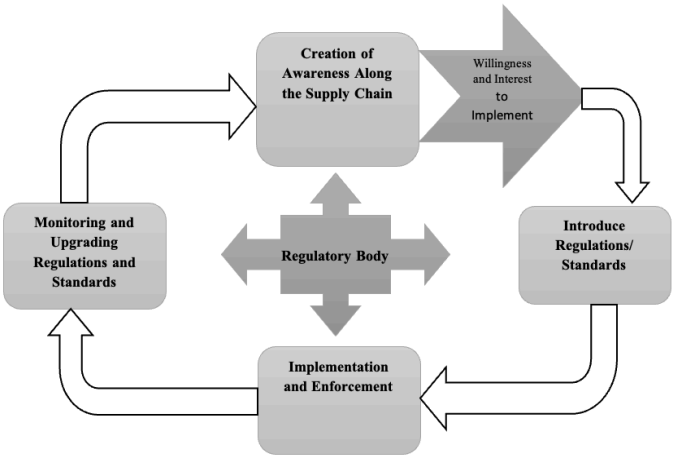

Figure 9: Regulations in the Implementation of FTS

Despite the importance of regulatory standards, the author posits that it is better to create an initial sensitization of the benefits of an FTS to gain stakeholder acceptance before introducing regulations to harmonize the implementation process. When FTS drove by internal motivation instead of obligatory regulations, it is bound to be successful and not seen as a burden. Figure 9 is a suggested framework to guide the implementation of FTS.

SC actors are fully aware of the need for FTSs; hence, the regulations only serve as a guideline to harmonize the implementation. This will help standardize voluntary traceability in areas with no regulations.

4.7 RQ5 State of Technology

Traceability's effectiveness is dependent on its ability to collect and transfer as much information as required by SC actors. Traceability systems in AFSCs currently range from paper-based to IT and a combination of both. The most appropriate technology depends on the information required and the type of food product. The current state of traceability technology is discussed below;

4.7.1 Internet of Things (IoT)

IoT has seen a significant rise in adoption in the agri-food sector in recent years [57]. It has presented an innovative, reliable, transparent, and auditable traceability system that contributes immensely towards fully satisfying consumers' SC goal [58]. In the AFSC, IoT plays a vital role in inventory and transportation visibility, and research has aided in its continuous upgrade of devices and sensors to increase its effectiveness. The current IoT-based traceability systems in the AFSCs are built to settle issues and concerns such as data integrity, counterfeiting, tampering, etc.,

4.7.2 Radio Frequency Identification (RFID)

RFID is an automatic identification technology that does not require direct contact with the product [59]. AFSCs activities ranging from planting/ rearing, harvesting/ slaughtering, processing, warehousing, distribution, and sales require a strict guarantee of quality and safety. RFID technologies have been widely accepted and implemented for this purpose for many years. It is the most used modern traceability technology because of its extra features, such as its ability to track multiple, fast-moving objects concurrently. RFID has the following advantages over other technologies. It can tag, store and manage a wide range of unique product information required at different parts of the supply chain and be modified to varying stages if needed [40].

It provides a temperature monitoring function that informs chain actors of any inconsistencies of temperature [40]. It enables long-distance tracking. It offers convenience, environmentally friendly (antipollution and recyclable), and more incredible information capacity [59].

The use of RFID tags has also been noted to have the following challenges and barriers; Maybe hindered by metal objects or extreme environments (wet, cold, etc.) distorting information flow[59].The relatively higher cost of implementation. Emerging RFID tags are focused on overcoming these challenges, but at increased cost; hence, only high-value products can bear the cost of these tags

4.7.3 Bar codes

The bar codes are an advanced technique used to capture data according to quality control standards to ensure compliance with other SC actors' requirements. Chrysochou, Polymeros [40] added that it performs similar functions as RFID but limited capacity. They said that bar codes are trendy because of their availability and ease of implementation; however, they can restrict product

information. The use of bar codes is falling out of popularity in the FTS because of its limitations and the extra effort and time required to execute; however, it guarantees credible product information [40].Concerning environmental sustainability, bar codes are environmentally friendly and can replace plastic devices to reduce ecological wastes.

4.7.4 Edible Marking Labels

Dominant in the fruit and vegetable industries use labels, one of the easiest and cheapest traceability levels an AFSC can adopt [40]. Product information such as product name, farmer, method of cultivation, required temperature for storage, expiry date, etc., are indicated on a label attached to either the product or its package. Chrysochou, Polymeros [40] noted that the use of labels, especially in fish, enhances consumer confidence since it reassures them of quality and safety. However, labels can only carry a small amount of information, and consumer needs direct contact with the product to access this information, thus slows down the shopping experience. Using a laser to print labels directly on fruits leaves an indelible mark to ensure continuous traceability may pose a health hazard.

4.7.5 Blockchain and IoT Technology

Blockchain technology is increasingly offering technological solutions across industries, including the agri-food industry. Its integration with IoT technology has proved very effective in FTS implementation (AgriBlockIoT). According to Caro, Pincheira [57], AgriBlockIoT creates transparent, auditable, absolute, and fault-tolerant records that are fundamental for the success of FTSs that is an emerging technology in FTSs, hence currently underexplored. However, it offers solutions that previous technologies could not achieve and has been considered the future of AFSC traceability. The farm-to-fork route can become more transparent and reliable with the use of AgriBlockIoT since the entire history of food can be stored in blockchains by participants as it travels along with the SC (i.e., from planting/ breeding to consumption).

5. Conclusion

The concept of traceability has seen a significant increase in adoption by AFSC partners for many reasons. Different motivations drive stakeholders; however, all SC partners' paramount focus is to deliver safe and quality food at the right time, at the right place for the right price to ensure consumer satisfaction and SC profitability.

The implementation of AFSC traceability is marred by different challenges such as the cost of set-up and management, technological deficiencies, unwilling partners, ineffective regulations and standards, etc. On the contrary, the long-term contributions of FTS implementation were enough motivation to drive SC actors into its practice.

The economic (profit), social (people), and environmental (planet) impact of AFSC traceability were enormous and worth the investment. Market share growth, minimum recalls, damage claims, labour savings, and production process improvements are a few of the economic benefits of FTS. Socially, FTS gives full detail about the source and composition of a food product; hence, allergies could be adhered to, and in times of food scares, food could be easily traced and recalled limiting casualties. FTSs also contributed to environmental sustainability by clearly indicating how to dispose of agri-food products and packages for recycling and renewable purposes.

Standards and regulations are critical in implementing FTSs; however, to meet consumers' increasing demands, FTSs have become more voluntary. A model was developed to explain how regulations. However, they do not initiate the implementation of FTSs was still fundamental to its implementation because it harmonizes the practice by creating standards to adhere to.

Technology was also found a vital role in the success of FTS implementation. It was discovered that cost and expertise as barriers to the full utilization of technology. The use of labels can be combined with bar codes or RFIDs to make it more useful and transferable. The accessibility of the internet could also increase the credibility of label information by providing scan codes on the product to access extra information that could not carry on the label. AgriBlockIoT presented a sophisticated alternative for FTS technology's future with the potential of providing participants with reliable real-time data. Sustainability practices and DCs in the supply chain are used among others to enhance traceability and tracking and to fulfil customer demands.

6. Limitations of the Research

The only limitation of this study is that it covers studies published between a specific period and studies only on a specific topic of traceability in agri-food. As per set criteria, only papers published in quality journals as per set inclusion and exclusion criteria were included in this review; therefore, this review's main limitation is that it has not included other articles published not fulfilling the given criteria.

7. Recommendations for Future Research

Researchers in AFSC traceability have focused mainly on backward tracing, leaving forward tracing (tracking) with little or untouched. Therefore, it is recommended that future researches be aligned towards forwarding tracking. FTSs are either non-existent or under patronized in developing countries, which can attribute to the cost and accessibility of relevant technology. However, governmental subsidies can serve as an incentive for SC actors to make AFSC traceability more prudent in developing countries, which ultimately brings an impact in developed countries. AFSC traceability has grown in global acceptability and brought various benefits; hence, there is a dire need for international organizations, such as FAO, to map out and enact internationally accepted frameworks and standards globally to increase voluntary participation and interoperability.

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