HOW RISK MANAGEMENT CAN BE IMPLEMENTED IN NEW AGRO-PRODUCT DEVELOPMENT (NAPD)?: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

New product development is highly complex because it integrates technical challenges from both internal and external sources. The potential for uncertainty or failure exists at every step of the product development process. One of the important tools to minimize risks in product development is risk management in new product development. This paper aims to review some research literature on the concept, process, and category of risk management in new agro-product development. This research uses a literature review analysis to analyze the concept and process of risk management in new product development. The articles were selected from Emerald, Elsevier, Springer, MDPI, and Taylor & Francis databases. The findings of this study demonstrate the critical role of risk management in minimizing risks associated with new product development through the implementation of diverse strategies. Risk management involves identifying, analyzing, evaluating, and treating risks. A variety of internal and external factors influence risk in product development. Internal factors are design, production, financial, management (organizational), marketing, market, technology, and supplier risks. External factors include suppliers, customers, and retailers outside the company. Many businesses, including small and medium-sized enterprises (SMEs), have adopted risk management to prevent product failures and financial losses. This paper provides a research framework for applying risk management to new agroindustrial product development.

Keywords: Agro-product; NAPD; New Product Development; Risk; Risk Management

INTRODUCTION

Agricultural products are characterized by perishability, short shelf life, and seasonal production (Osman et al., 2023; Shukla and Jharkharia, 2013). These products are highly susceptible to changes in temperature, humidity, and improper handling (Rijpkema et al., 2014). Based on Behzadi et al. (2018), agro-products have two main categories: crops (like fruits and vegetables) and livestock (like meat and dairy). These products can either spoil quickly or last a long time. Products that spoil easily, like fresh fruits and meat, are more likely to have problems due to their biological nature. The classification of agro-products can be seen in Figure 1.

Fluctuations in the quality and quantity of harvested produce are common due to environmental factors and pests (Moazzam et al., 2018). The harvesting process of agricultural products often generates byproducts. Byproducts are unwanted materials that arise during the sorting process of agricultural products. According to Srivastava et al. (2023), agricultural wastes are generated as unwanted matter or by-products from agricultural operations. Agricultural by-

products, generated during various stages of agricultural operations and food processing, contain numerous nutritional, functional, and bioactive components that can be utilized to develop innovative food products, reduce waste, and enhance the overall sustainability of the food system (Comunian et al., 2021; Raţu et al., 2023). New product development (NPD) in the agro-industrial sector can support adding value to products and increase selling value.

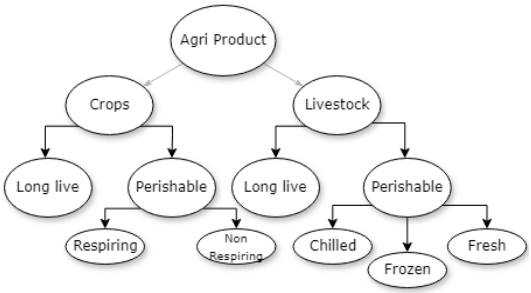

Figure 1. Classification of agro-product (modified from Behzadi et al., 2018)

NPD is crucial for the continued growth and success of businesses (Shafqat et al., 2019). By consistently creating new products, companies can maintain relevance in response to changing customer needs and avoid outdated (Fakhreddin and Foroudi, 2022). Even when research and development costs surpass half the allocated budget for a new product, a company only risks a 4% loss if they manage to introduce the product on schedule (Chiu et al., 2022). Manufacturers must rapidly introduce new products to maintain a competitive edge. Corporate growth depends on the success or failure of new product development (Lyu et al., 2022). According to a survey, leading companies have a significantly higher success rate (73%) in new product development than lagging companies (27%). Companies allocate substantial resources to new products as they can provide solutions to the problems they face (Chiu et al., 2022).

New product research and development projects often need help with bottlenecks and risks, resulting in frequent plan changes that affect labor, materials, and equipment scheduling. In severe cases, this requires rework, impacts R&D schedules, increases costs, and reduces product quality (Mousavi et al., 2021; Oehmen et al., 2014). Researching customer needs and market trends helps reduce uncertainty about product requirements (Oehmen et al., 2014). Developing, testing, and evaluating new technologies clarifies their capabilities and costs. Improving and standardizing the new product development process within the organization increases the reliability of the development process (Mu et al., 2009). Reducing risks in new product development can also enhance customer value and serve as a tool for analyzing and optimizing product development processes (Bassler et al., 2011; Browning et al., 2002).

This research aims to review existing literature on the concept, process, and category of risk management in new agricultural product development (Figure 2). This will be valuable for industry practitioners, academic theorists, and society. However, assessments that consider all three aspects (risk management, new product development, and agricultural products) are scarce to identify synergies and support the development of more comprehensive management models.

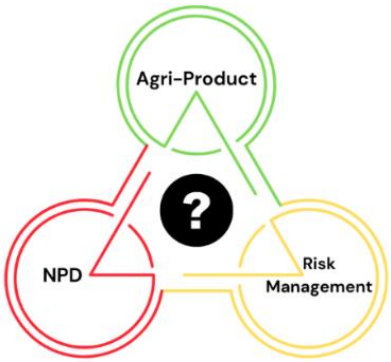

Figure 2. The aim and scope of the review

METHOD

This study employs two primary methods, consisting of a systematic literature review (SLR) and an analysis of past articles. A systematic literature review (SLR) enables the consolidation of disparate works on a given topic, the synthesis of their findings, the delineation of discrepancies, and the advancement of the existing body of knowledge (Nurfitriani et al., 2022; Yadav et al., 2022). The research phases are presented in Figure 3.

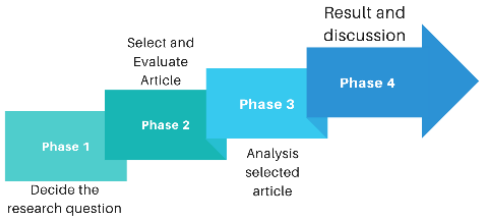

Figure 3. Research phase (modified from Bastas and Liyanage, 2018)

Phase I: Decide the research question

Formulating a research question is a pivotal stage in conducting a literature review. A well-defined research question is a compass, guiding the entire research process and ensuring the investigation remains focused and relevant (Barroga and Matanguihan, 2022). The research question in this study is the following: *"How is the integration of the concepts, processes, and factors of risk management in the development of new products in the agro-industrial sector?"*

Phase II

The second phase of the process entails the selection and evaluation of articles. The article search was conducted using the Perish or Publish software, with the results limited to the period between 2014 and 2024. The search was conducted on the Scholar and Scopus databases. The search keywords were divided into strings as follows:

- String I: Risk Management in Agri-Product
- String II: New Agri-Product Development/Innovation; product development from agricultural by-products
- String III: Risk Management in New Product Development
- String IV: Risk Management in New Agri-Product Development

Figure 4 illustrates the process of selecting articles for review. The selection process generated a list of 30 articles identified as potentially relevant for combining used keywords. VOSviewer software is used to build and visualize the relationship of bibliometric sources to top author sources to extract information in the form of keyword trends in the field of study (Hallinger and Nguyen, 2020).

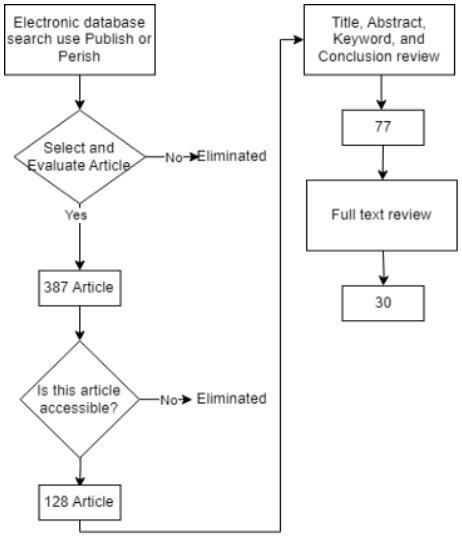

Figure 4. Article selection process

Phase III

This phase refers to critically examining and evaluating the individual studies. The identification process is also performed on each selected article to answer the research objectives.

Phase IV

This phase will present the findings of the research review, offering a synthesis of the data, an analysis of its key features, and an interpretation of its implications.

RESULT AND DISCUSSION

Keywords Analysis

Keyword analysis is a fundamental technique in literature reviews, bridging the breadth of academic literature and the specific research question (Corrin et al., 2022). By conducting a thorough keyword analysis, researchers can lay a solid foundation for their literature review and ensure their investigation is comprehensive, focused, and informative. This research provides a keyword analysis to guide the search for relevant studies, ensuring that the literature review is manageable by irrelevant material. The keyword results are shown in Figure 5.

Five clusters were obtained from the keyword analysis performed. Cluster 1: Products, agriculture, risk factors, food, and control. This cluster highlights the

relationship between agricultural products, their associated risks, and the need for effective control measures. Cluster 2: Customer Integration, Issues, Resilience, Methodology, Innovation. This cluster focuses on developing innovative methodologies and building resilience to address potential issues arising from customer interactions. Cluster 3: Farmers, Trade, Value, Costs, Waste. This cluster highlights the linkages between farmers, trade activities, product value, cost, and waste management in the agricultural supply chain. Cluster 4: Severity, AFSC (agri-food supply chain), challenges, innovation. This cluster highlights the linkages between challenges, severity, innovation, and agri-food supply chains (AFSCs). The need for innovation and overcoming severe challenges is directly linked to the overall sustainability and resilience of agricultural supply chains. Cluster 5: New Product Development, Risk Management Practices, Performance, Issues, Customer Integration. This cluster focuses on innovation, challenges, and performance. Successful development and introduction of new products can contribute to the overall sustainability and competitiveness of the company.

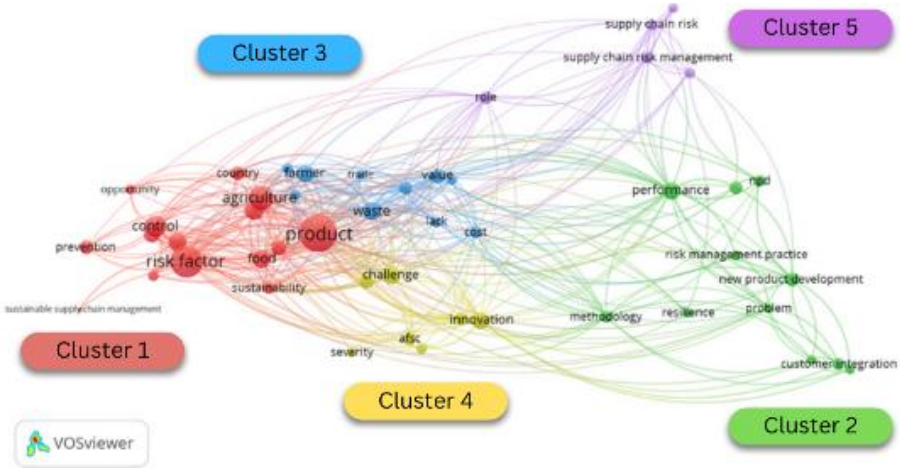

Figure 5. Keyword distribution

Overview of Literature

Following the elimination of duplicates, the reading of abstracts, and a thorough examination of the content, 30 relevant articles were identified (Table 1). The articles were selected from Emerald, SSRN, Elsevier, Springer, MDPI, and Taylor & Francis databases.

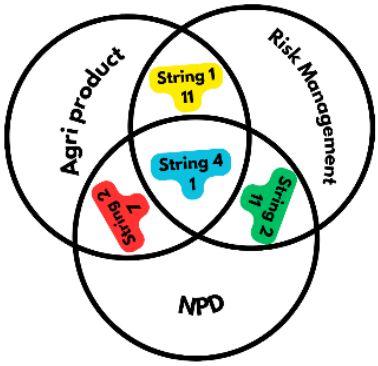

Figure 6. Proportion of string

The Venn diagram (Figure 6) visually represents the interconnectedness between agricultural products, risk management, and new product development (NPD). The three overlapping circles illustrate the intersections between these concepts. Agricultural products, ranging from crops to livestock, are inherently linked to risk management. Identifying, assessing, and mitigating risks is crucial for ensuring the sustainability and profitability of agricultural ventures. Moreover, developing new agricultural products requires careful risk assessment to ensure market viability and minimize potential losses. Risk management and NPD overlap, emphasizing integrating risk considerations into product development. By proactively addressing potential challenges and uncertainties, businesses can increase the likelihood of successful product launches and long-term market success.

Table 1. Overview of literature

No	Authors	Year	Title	String	Publisher	Research Methodology	
						Review	Study Case
1	Qian and Olsen	2020	Financial and risk management in agricultural cooperatives with application to the milk industry in New Zealand	1	Taylor & Francis		v
2	Zhai et al.	2022	Assessment of the agriculture supply chain risks for investments of agricultural small and medium-sized enterprises (SMEs) using the decision support model	1	Taylor & Francis		v
3	Zandi et al	2020	Agricultural Risk Management Using Fuzzy TOPSIS Analytical Hierarchy Process (AHP) and Failure Mode and Effects Analysis (FMEA)	1	MDPI		v
4	Zhao et al.	2021	The effects of agro-food supply chain integration on product quality and financial performance: Evidence from Chinese agro-food processing business	1	Elsevier		v
5	Waqas et al.	2023	Influence of supply chain risk management and its mediating role on supply chain performance: perspectives from an agri-fresh produce	1	Springer	v	
6	Tigre and Heshmati	2023	Smallholder farmers' crop production and input risk analysis in rural Ethiopia	1	Taylor & Francis	v	
7	Cornaggia, 2013	2012	Does Risk Management Matter? Evidence from the U.S. Agricultural Industry	1	Elsevier	v	
8	Komarek et al.	2021	A review of types of risks in agriculture: What we know and what we need to know	1	Elsevier	v	
9	Duong et al.	2019	A Global Review of Farmers' Perceptions of Agricultural Risks and Risk Management Strategies	1	MDPI	v	
10	Assouto et al.	2020	Price risk and farmers' decisions: A case study from Benin	1	Elsevier		v
11	Moazzam et al.	2018	Measuring agri-food supply chain performance and risk through a new analytical framework: a case study of New Zealand dairy	1	Taylor & Francis		v
12	Caiazza et al.	2016	Innovation in Agro-Foods: A Comparative Analysis of Value Chains	2	Taylor & Francis	v	
13	Otsuka and Ali	2020	Strategy for the development of agro-based clusters	2	Elsevier	v	
14	Aibar-Guzmán et al.	2022	Sustainable product innovation in agri-food industry: Do ownership structure and capital structure matter?	2	Elsevier	v	
15	Solarte-Montufar et al.	2021	Open Innovation in the Agri-Food Sector: Perspectives from a Systematic Literature Review and a Structured Survey in MSMEs	2	MDPI	v	
16	Duangpapeng et al.	2018	Corn Tassel: A New Source of Phytochemicals and Antioxidant Potential for Value-Added Product Development in the Agro-Industry	2	MDPI		v
17	Srivastava et al.	2023	Biorefineries development from agricultural byproducts: Value addition and circular bioeconomy	2	Elsevier		v

No	Authors	Year	Title	String	Publisher	Research Methodology	
						Review	Study Case
18	Raţu et al.	2023	Application of Agri-Food By-Products in the Food Industry	2	MDPI	v	
19	Salavati et al.	2016	Improving new product development performance by risk management	3	Emerald	v	
20	Chauhan et al.	2018	Examining the State of Risk Management Research in New Product Development Process	3	Taylor & Francis	v	
21	Akram and Pilbeam	2015	Critical success factors for effective risk management in new product development	3	IEEE Xplore	v	
22	Dewi et al.	2015	Risk management in new product development process for fashion industry: Case study in hijab industry	3	Elsevier		v
23	Bastchen et al.	2018	Risk management analysis in the product development process	3	Elsevier	v	
24	Peljhan and Marc	2023	Risk management and strategy alignment: influence on new product development performance	3	Taylor & Francis	v	
25	Oehmen et al.	2014	Analysis of the effect of risk management practices on the performance of new product development programs	3	Elsevier	v	
26	Schulte et al.	2020	Strategic Sustainability Risk Management in Product Development Companies: Key Aspects and Conceptual Approach	3	MDPI	v	
27	Song et al.	2013	Risk evaluation of customer integration in new product development under uncertainty	3	Elsevier	v	
28	Chiu et al.	2022	Identifying Key Risk Factors in Product Development Projects	3	MDPI	v	
29	Shafqat et al.	2019	Resilience in product design and development processes: A risk management viewpoint	3	Elsevier	v	
30	Donner et al.	2021	Critical success and risk factors for circular business models valorising agricultural waste and by-products	4	Elsevier	v	

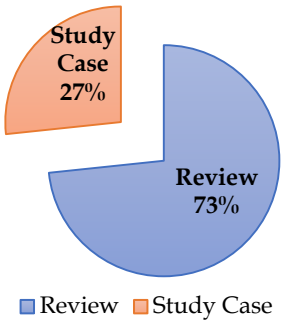

Figure 7. Research methodology

Research Methodology

The research methodology for this literature is a mixed approach, combining case studies and literature reviews. The pie chart suggests that 73% of the research will review existing literature, while 27% will involve in-depth case studies. This mixed approach could provide a comprehensive understanding of the research topic by drawing from both theoretical and empirical evidence. The research methodology can be seen in Figure 7.

Publish Area

Figure 8 shows a bar chart representing the frequency or number of publications of different academic publishers based on the four specified strings. Elsevier is the most prolific publisher based on the highest bar, indicating that it has published the most articles or papers of the publishers listed. The analysis showed that 90% of the publications were in journals and 10% in proceedings (Figure 9). This shows that more articles are published as journals than as proceedings.

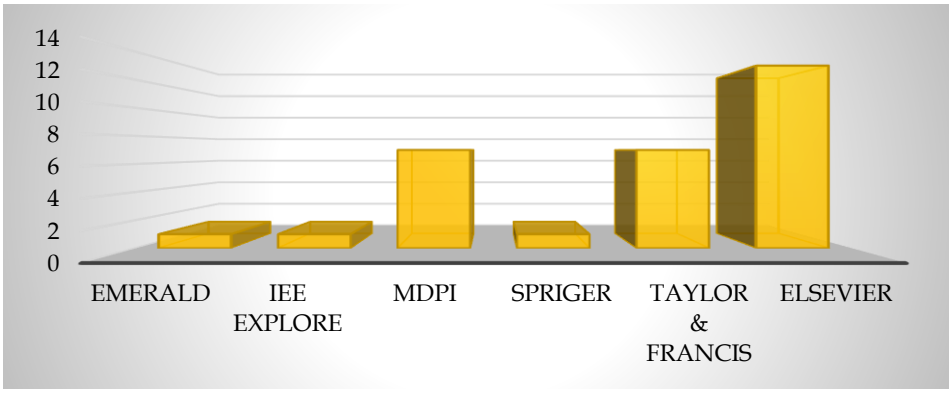

Figure 8. Distribution of articles across publisher

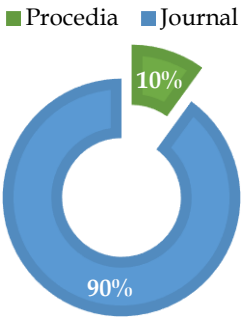

Figure 9. Type of Publication

Risk Management in New Agro-Product Development

Risk management in new product development projects has been a subject of ongoing interest among researchers. Several management philosophies exist regarding new product development that focus on managing different types of risks (Chiu et al., 2022; Moazzam et al., 2018; Oehmen et al., 2014; Song et al., 2013). Risks are intrinsic in new product development (NPD) in all industries (Dewi et al., 2015; Moazzam et al., 2018; Qian and Olsen, 2021). The NPD process introduces something new to the market, so there is always a chance of failure. Thus, firms need to take initiatives to reduce risks related to NPD.

Risk management is crucial to the new agro-product development process (Donner et al., 2021). It involves identifying, assessing, and treating potential risks that could hinder the successful introduction and commercialization of a new product (Bassler et al., 2011; Chauhan et al., 2018; Giannakis and Papadopoulos, 2016). Many

studies discuss developing products that use raw materials for agro-industrial products, including fresh materials or by-products (Duangpapeng et al., 2018; Rațu et al., 2023; Srivastava et al., 2023). Product development in the agro-industrial sector is also subject to risks. At each stage of product development, risk management should be carried out. Each stage of product development is very complex, especially product raw materials is agricultural industry materials, which have characteristics in each product (Osman et al., 2023; Shukla and Jharkharia, 2013). The stages in product manufacturing can be seen in Figure 10.

ISO 31000 offers a comprehensive framework for risk management that helps organizations align with international standards and ensure consistent practices across their operations (Chiu et al., 2022). Also, it addresses the management system surrounding the risk management process (Bassler et al., 2011). The ISO generic risk management process claims to apply to organizations and functions within organizations across sectors (Lalonde and Boiral, 2012). With the adoption of ISO 31000, the risk management process in New Agricultural Product Development (NAPD) can be seen in Figure 10.

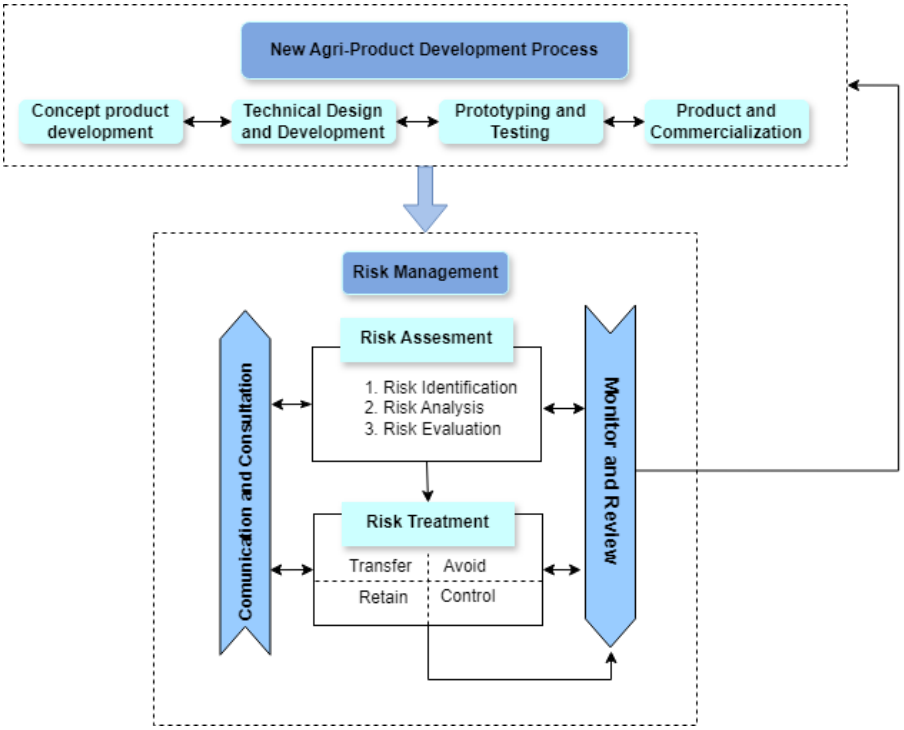

Figure 10. RM process in NAPD (modified from ISO 31000; Bassler et al., 2011; Chauhan et al., 2018; Giannakis and Papadopoulos, 2016)

1. Risk Assessment

- **Risk Identification:** This involves identifying potential risks that could impact the development and commercialization of the new product (Bassler et al., 2011; Chiu et al., 2022; Kheir et al., 2022). These risks can be categorized into market, technological, production, financial, regulatory, and strategic risks, or others (Dewi et al., 2015; Moazzam et al., 2018; Oehmen et al., 2020; Song et al., 2013)
- **Risk Analysis:** Once risks are identified, they must be analyzed to assess their likelihood and potential impact on the project (Bassler et al., 2011). This can be done using various techniques, such as risk matrices or probability and impact assessments (Liu et al., 2023; Zandi et al., 2020)
- **Risk Evaluation:** Based on the analysis, risks are evaluated to determine their significance and priority. High-priority risks require

immediate attention, while lower-priority risks may be addressed later (Kheir et al., 2022; Ullah et al., 2024).

2. Risk Treatment

Based on the research conducted by Giannakis and Papadopoulos (2016), 4 Treatment Actions can be adapted to help manage risk, as listed below:

- **Transfer:** This involves shifting the risk to a third party, often through insurance or contracts. For example, purchasing insurance can transfer the risk of property damage or product liability.
- **Avoid:** If a risk is deemed too high, it may be possible to avoid it altogether by modifying the project or making alternative decisions.
- **Retain:** Some risks may be accepted and retained, especially if they are considered low-impact, or mitigation strategies are in place.
- **Control:** This involves implementing measures to reduce the likelihood or impact of a risk. Examples of control measures include quality control procedures, contingency planning, and risk mitigation strategies.

Table 2. Risk category in NAPD

Risk Category	Description	Stakeholder analysis	Implementation	References
Design and production	Risks related to the design and production phases of a product	Internal firm	Small Medium Enterprise, Medium Enterprise, Large Enterprise	Chiu et al. (2022); Dewi et al. (2015); Enyoghasi and Badurdeen (2021)
Financial	Risks related to the financial aspects of a product development project	Internal firm	Small Enterprise, Small Medium Enterprise, Medium Enterprise, Large Enterprise	Assouto et al. (2020); Dewi et al. (2015); Komarek et al., 2020; Moazzam et al., 2018; Qian & Olsen, 2021b; Stosic et al., 2017; Zandi et al., 2020b)
Management (Organizational)	Risks associated with the management and leadership of a product development project	Internal and external firm	Small Medium Enterprise, Medium Enterprise, Large Enterprise	(Chiu et al., 2022; Moazzam et al., 2018; Salavati et al., 2016; Zandi et al., 2020)
Marketing	Risks related to the marketing and commercialization of a product	Internal and external firm	-	(Salavati et al., 2016; Stosic et al., 2017; Zandi et al., 2020)
Market	Risks related to the broader market environment in which a product operates	Internal and external firm	-	(Chiu et al., 2022; Komarek et al., 2020; Moazzam et al., 2018; Oehmen et al., 2020; Salavati et al., 2016)
Technology	Risks associated with the implementation of technologies used in product development	Internal firm	Medium Enterprise, Large Enterprise	(Chiu et al., 2022; Salavati et al., 2016; Stosic et al., 2017)
Supplier	Supplier risk is associated with the potential negative consequences that an organization may face due to the actions or inactions of its suppliers	External firm	Small Medium Enterprise, Medium Enterprise, Large Enterprise	(Chiu et al., 2022; Flankegård et al., 2021; Moazzam et al., 2018)

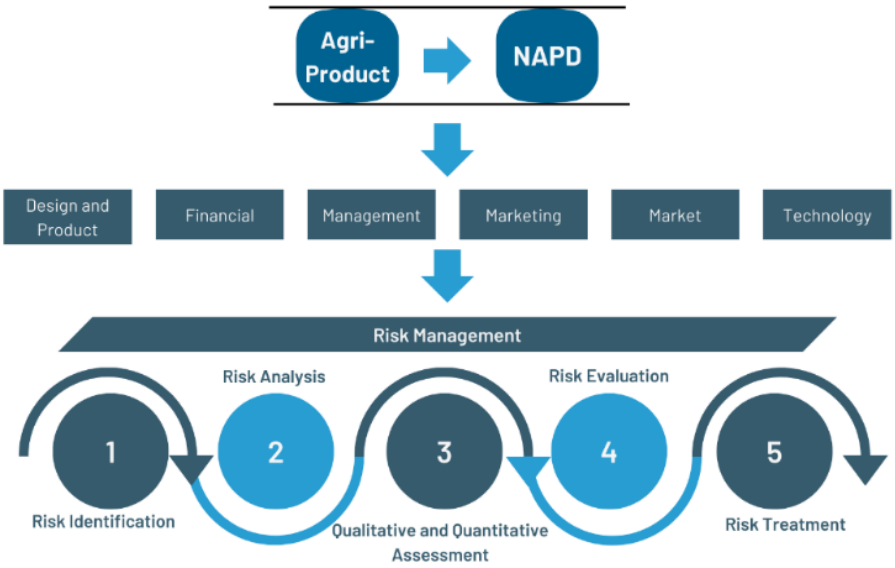

Figure 11. Framework for future research in applying risk management to NAPD

3. Monitoring and Review

- **Continuous Monitoring:** Risks must be monitored throughout the project for their likelihood or impact changes.
- **Regular Reviews:** Periodic reviews should be conducted to assess the effectiveness of risk management strategies and identify any new emerging risks.
- **Communication and Consultation:** Effective communication and stakeholder consultation are essential for successful risk management. This includes sharing information about identified risks, mitigation strategies, and any changes in the risk landscape.

Risk Category in New-Agri Product Development

Table 2 outlines various risk categories commonly associated with NAPD projects. The most identifiable risk categories are design and production, financial, management (organizational), marketing, market, technology, and supplier risks.

Framework for Future Research

This paper provides a research framework for applying risk management to new agroindustrial product development. Figure 11 shows that risk management should be integrated throughout the NPD process, from the initial design and production stages to the final marketing and technology aspects. This ensures that risks are considered and addressed at every stage of the product development cycle.

Figure 11 represents the starting point of the NPD process, where the specific agricultural product to be developed is identified. It is essential to integrate risk management at all stages of the product development process. The initial step is to identify the risks that could potentially affect the success of the NPD project (Oehmen et al., 2020). These risks can be categorized into design and production, financial, management, marketing, market, technology, and supplier risks. After identifying potential risks, it is essential to evaluate their possible consequences and the chances of them happening. This involves qualitative and quantitative assessments (Zandi et al., 2020). Based on the risk evaluation, appropriate risk treatment strategies can be implemented. These strategies may include risk avoidance, reduction, transfer, or acceptance.

CONCLUSION

Agricultural products have perishable characteristics, short shelf life, and seasonal production. Product development in the agro-industrial sector can help add value to products and increase sales value. Developing new products is complex because it involves integrating

technical challenges from both internal and external sources. The potential for uncertainty or failure exists at every step of the product development process. Risk management in new product development is an important tool for risk mitigation in product development. Risk management in NAPD is applied by adopting the risk stages set out in ISO 31000, which has a risk assessment and handling steps, each requiring communication and monitoring. This study identified risk categories in NAPD, including design and production risk, financial risk, management (organizational) risk, marketing risk, market risk, technology risk, and supplier risk.

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