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Analysis of the Effective Key Factors on Process-based Innovations in Sugarcane Industries via Meta-Synthesis

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Abstract

Sugarcane industry is a pivotal force in agricultural perspective. It is essential to promote process innovations in sugarcane planting for sustainable growth and competition. This study was conducted to analyze the effective key factors on process-based innovations in sugarcane industry. It is applicable from objective aspect and the required data was collected through qualitative method and meta-synthesis. Finally, 33 related articles were identified via meta-synthesis. Validity of the research was confirmed based on the inclusion criteria, holding sessions with members of the research team, the use of an expert and examination of the whole process for theoretical consensus. Reliability was also determined via Critical Appraisal Skills Program. The effective dimensions and components on process-based innovations in sugarcane industry include four dimensions, namely steps of innovation in sugarcane production cycle that have been identified in the form of 45 components. The dimensions are "innovation in the process of planting", "innovation in the process of growing", "innovation in the process of harvesting" and "innovation in the process of processing". This study provides a map to understand the multi-faceted perspective of process-based innovation in sugarcane industry. Through classification of the components in vital stages, stakeholders achieve insight on transformational strategies and reinforce sustainable methods which are technologically advanced in sugarcane planting.

Keywords: Innovation, Process Innovation, Sugarcane Industry, Meta-Synthesis, Key Factors

1. Introduction

Firms have to look for innovative ways to remain, simplify operations and respond to transformation of consumer needs (Gutiérrez Cano et al., 2023). In this scope, sugarcane industry, building block of the agriculture sector, is not an exception. The concept of process innovation in the ever-changing perspective of industries is regarded as a light for progress and efficiency. Process innovation includes execution of new methods, techniques or strategies to reinforce operating processes in an industry. The current market has become highly competitive and it is necessary for all firms to be able to maintain their competitive situation in this complicated space that is full of information and knowledge (Jafari et al., 2023). To understand the importance of process innovation in sugarcane industry, recognition of the axial role that sugarcane plays in the global framework of agriculture is necessary. With a century old history, sugarcane planting has become a complex and dynamic industry and is effective on economies and livelihood across the world. Beyond its role as the main source of sucrose for making the world sweet, sugarcane has diversified its share and has appeared as a vital player in biological production (Munyoro & Tyorera, 2023). Dual identity of sugarcane as a sweetener and a source of renewable energy underlines its multi-faceted importance. Sucrose extracted from sugarcane not only sweetens numerous products but also acts as a raw material for production of ethanol, a renewable biological fuel. This duality places the sugarcane industry at the intersection of food security and energy and converts it to an important sector for sustainable development (Verma et al., 2022).

In different industries, including the sugarcane industry, process innovation plays an important role. From agricultural methods and harvesting techniques to refining and distribution processes, firms are trying to remain competitive and conform with the changing demands in the market. It is essential to understand the dimensions and components of process innovation for industries with the aim of moving in complexities of modern markets and reinforcing sustainable growth (Silva et al., 2019).

Process innovation shows intentional transformation of methods, technologies or strategies of a firm to reinforce operational efficiency and effectiveness. This innovation expands beyond increasing progresses that often includes a basic revision on how to perform tasks and use the resources. The major purpose of process innovation is workflow optimization, cost reduction and improvement of total performance of a firm. In its main core, process innovation involves identification and execution of new approaches for the tasks and activities and leads to simplification of operations and increasing of productivity. This issue can contain changes in technology, workflow redesign and integration of cutting tools or methods. Successful process innovation is determined via its capability in offering tangible advantages either through increased production, improved quality or enhanced flexibility in responding to market dynamism (Sadiki & Lebailly, 2021).

Munyoro and Tyorera (2023) explored the role of innovation in sugarcane industry growth in Zimbabwe and showed that various challenges prevent the growth of sugarcane industry among which lack of innovation, inadequate financial resources, lack of access to modern technology, weak culture of innovation, economic instability and lack of foreign exchange, high inflation, instability of foreign exchange and inconsistency of politics can be mentioned. This study maintains that modification of sugarcane as well as agricultural methods in sugarcane production like crop rotation, product protection, water management, soil management, nutrients management, and mechanized harvesting are the required cases that must be created. On the other hand, Kadam et al. (2023) explored increased production of sugarcane through identifying and eliminating main limitations of farmers. This study has identified several considerable limitations throughout adopting sustainable planting methods in sugarcane that include high costs of complex fertilizers, labor cost, inadequate accessibility of the required earthworm and lack of pricing based on recycling. In return, farmers presented valuable suggestions such as granting credit with lower and timely interest rate, reducing the costs of complex fertilizers and doing a show or experiment at the farm by different methods of sustainable planting to show their effectiveness.

Gutiérrez Cano et al. (2023) investigated innovation and development technologies, sustainability, the use of information and communications technology, training and propagation in agricultural innovation system and suggested participation of cooperatives, technology platforms and farmers' organizations as the related intermediaries for closing system gaps given the restrictions of process innovations of agriculture. In addition, Baiyegunhi et al. (2023) stated in their survey that there are evidences regarding lack of technical and managerial knowledge among the emerging sugarcane farmers that enjoy the Land Reform Program in South Africa. Therefore, it restricts their total potential in terms of innovation and productivity that is harmful for their competitiveness. The obtained results confirmed causal relations between human capital (on-the-job training) and innovative behavior of farms that has a positive effect on farm productivity. This result shows the relationship between human capital development in increasing of innovation and productivity of the agriculture sector. Also, Solomon et al. (2022) stated in their research that purpose of the global sugar industry must be continuous compatibility to remain competitive in an environment with increase in costs of production, climate variability, biological and non-biological tensions, coping expenses and change in production and consumption patterns due to recent epidemics. However, sugar industry has the required potential for positive effect and helping a number of key issues related to comprehensive and sustainable development through different ways that includes extraction of the potential of technological innovation in some fields like biological energy, green harvesting and sustainable waste use, separation, weather resistant species, agriculture 4.0 and agricultural technologies, production of intensive biological products and conservation technologies, water management in the field and process, zero pollution discharge, steam recycling, biomass valuation, cellulose, lignin, cellulose ethanol, fuel cell technology, biological fuels and aviation fuel, organic and special sugars, green manure and degradable plastic and biological products with pharmaceutical and industrial importance.

In their survey, Palacios-Bereche et al. (2022) indicate that sugarcane industry has a high importance for a country and as this industry produces energy, undoubtedly energy management is important for its industrial process. This survey deals with various alternatives to improve the industrial process of sugarcane in order to optimize energy management. The below suggestions can be proposed: increasing of electrical energy in simultaneous production, heat integration of process flows, production of second generation ethanol, water consumption in the process, integration with production of biodiesel to enhance energy production and decrease pollution.

To compete in the existing space, turning to innovation and subsequently its management have become important more than ever. Innovation management can create competitive advantage for companies (Hosseini Shakib & Moradian, 2018). Bagheri and Javadi (2022) evaluated technology level in production of strategic agricultural products in Iran and maintained that today, improving productivity in agricultural production is only possible via the use of technology given the limited production resources and population growth. And to improve the technology level in production of agricultural products, monitoring the current situation of technologies in use is needed in the first step. Moreover, Araújo et al. (2010) showed importance of technology progress in sugarcane production and its effect on economy of brazil in their study. This study is focused on advances obtained from producing various new products with special features and developing the new products and by-products of sugarcane industrialization. Special attention has been paid to growth and increasing importance of the product in local and national economies that have been displayed based on the value of harvesting and production forecasting in future. This study concludes that the sugarcane sector has become the most important and competitive sector in the world due to agricultural and industrial evolution of technology in recent past.

Innovation is necessary for responding to vital concerns of the society such as climate change, global warming, lack of food/energy and security, environmental challenges or the use of resources/sustainability.

According to the results, all indicators of innovation management, i.e. creating innovation, innovation organization, innovation planning, financing and creating the infrastructure to facilitate innovation, paying attention to applied strategies of innovation, innovation research and development, development of innovative human resources, dissemination of innovation, organizational transformations toward innovation, the use of innovation and marketing of new products had significant difference under current conditions and favorable conditions with 99 percent probability.

Despite obvious importance of process innovation in sugarcane industry, there is a considerable research gap in understanding certain dimensions and components that give rise to this challenge. While the current studies address more extensive aspects of agricultural innovation, there is not a comprehensive analysis of unique challenges and opportunities in sugarcane sector. The existing literature is mainly focused on agricultural or industrial aspects of sugarcane supply chain and neglects correlation of these elements. Through dealing with this gap and using qualitative meta-synthesis, the present study aims to create a more comprehensive understanding of the effective factors on process-based innovation in sugarcane industry.

This study has been carried out to address the existing research gap through conducting qualitative research of the findings obtained from various studies to identify the effective key factors on process innovations in sugarcane industry. It attempts to help the current knowledge body and presents a valuable insight for industry stakeholders, policymakers and researchers in the field of sugarcane industry. Importance of this attempt lies in its potential to direct future studies and inform practical strategies to reinforce innovation in sugarcane sector. Policymakers can make use of the created insights in this research to design informed strategies in process innovations of the sugarcane industry which reinforce innovation, enhance productivity, and strengthen environmental, economic and social sustainability. On the other hand, industry stakeholders can utilize these findings to optimize their operations, competition and help more extensive purposes of the future of agriculture and sustainable energy.

Thus, the main research question is stated as below: what are the key factors which are considerably effective on process-based innovations in sugarcane industry?

2. Materials and Methods

This study is applicable from objective aspect and Sandelowski and Barroso's meta-synthesis (2007) has been employed. This approach includes regular study of findings of qualitative research and a new interpretation is created through seven stages. These stages are: proposing the research question and objectives, systematic review of texts, searching and choosing relevant articles, extraction of information and results of articles, analysis and combination of qualitative findings, quality control and presenting the findings. Details of these stages are displayed in Figure 1. Parameters related to *selection criteria* of articles including period of publication, analysis method based on the research objective and other criterions have been determined. Based on the research objectives, a systematic review of the qualitative research findings has been conducted. To investigate, key words such as process innovation in the sugarcane industry, process innovation in agriculture, process innovation in the food industry, process innovation in the planting, process innovation in the growing, process innovation in the harvesting, and process innovation in the processing were employed. These searches were used in titles, abstracts and keywords of published articles. The inclusion criteria contained non-Persian qualitative articles related to the research question that have been published in databases such as Taylor and Francis, Wiley, Springer, Emerald, Elsevier, and Peterson Institute for International Economics in years 2010-2023 and certainly had Scopus index or ISI-Listed or ISI-WOS. Likewise, Persian qualitative articles related to the research question were also studied that have been published in reputable scientific *journals* in the above-mentioned years, had free access and were indexed by databases including Magiran, SID and Civilika. Thus, the inclusion criteria led to omission of unjudged documents like books and theses as well as articles with questionable citations from the list so that research validity was enhanced. Frequency of articles in databases is shown in Table 1.

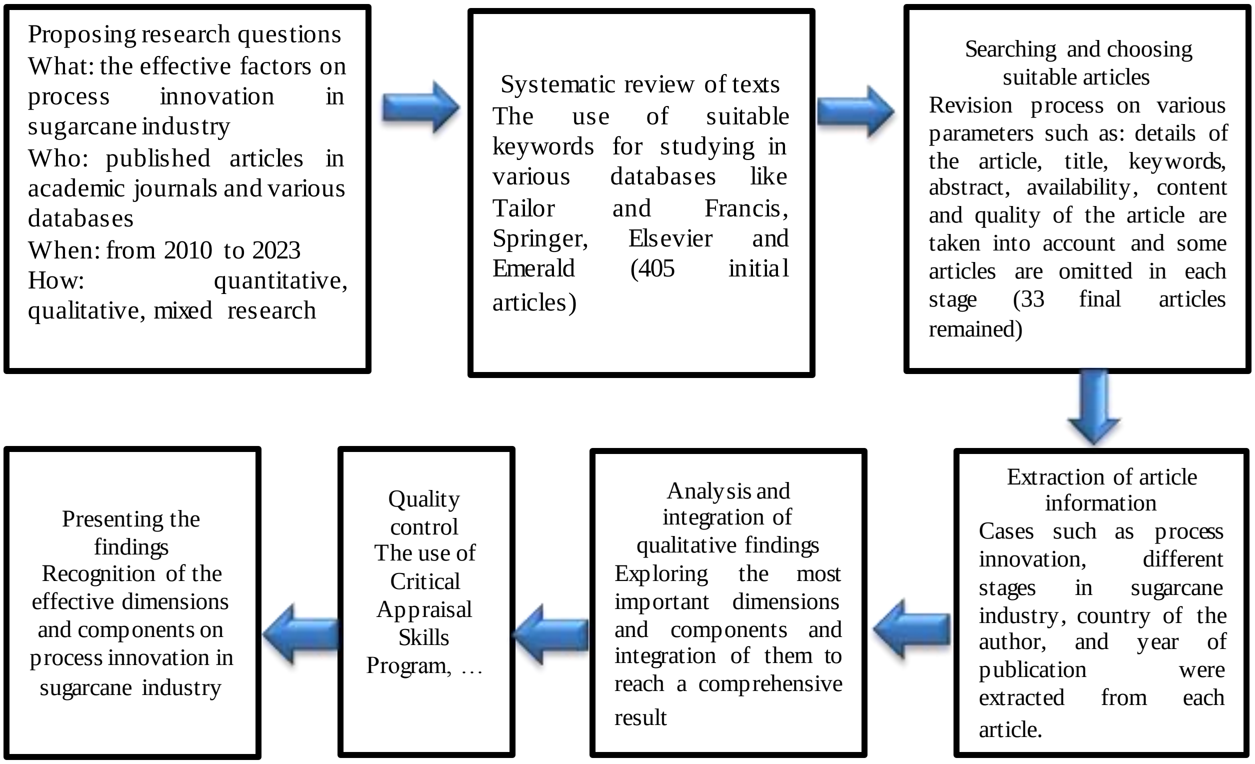

Figure 1. Details of carrying out research based on meta-synthesis

Table 1. Frequency of articles in databases

Data base	Total frequency	Frequency of final articles
Taylor and Francis	39	0
Wiley	92	7
Springer	42	2
Emerald	83	9
Elsevier	75	11
Peterson Institute for International Economics	15	2
Magiran	14	0
SID	17	1
Civilika	28	1

Considering the table 1, 405 initial articles were found in databases. The inclusion criteria led to omission of 372 articles out of 405 primary articles and entry of 33 articles related to the research question. The stages are shown in Table 2.

According to the above table 2, 33 final articles were selected. Validity of the research has been confirmed based on Sandelowski and Barroso's method (2007) throughout the research and by means of various mechanisms as below:

- The use of inclusion criteria, holding weekly sessions to report searching of articles, the use of Endnote software to save the articles and study them to enhance descriptive validity
- holding weekly sessions and evaluation of team members' report to enhance interpretive validity
- the use of a specialist to enhance theoretical validity
- examination of total process for theoretical consensus by all experts and researchers to enhance practical validity

Table 2. Method of choosing final articles

Stages	The number of articles under study	The number of omitted articles	Why articles were omitted
Searching of keywords in databases	Inclusion of 405 articles and studying the titles	Exclusion of 235 articles	Irrelevance of the title, not indexing of the non-Persian journal in Scopus or ISI-Listed or ISI-WOS and repetitive articles in Persian databases
Studying the selected articles in previous stage	Inclusion of 170 articles and studying the abstract	Exclusion of 89 articles	Irrelevance of the objective, non-qualitative method
Studying the selected articles in previous stage	Inclusion of 81 articles and studying the whole article	Exclusion of 33 articles	Irrelevance of the objective, non-qualitative method, irrelevance of the findings
Studying the selected articles in previous stage	Inclusion of 48 articles and consultation for theoretical consensus	Exclusion of 15 articles	Irrelevance of the objective, non-qualitative method, irrelevance of the findings, research plan inconsistent with the research objective
The number of final articles	Inclusion of 33 articles related to research objective		

Research reliability has been measured using the Critical Appraisal Skills Programme (2018) by team members and a proficient expert to assess quality, accuracy, credit and significance of final articles through 10 questions including 1) clarity of research objectives, 2) logic of methodology (qualitative), 3) compatibility of the research plan to achieve the objectives, 4) compatibility of the sampling method to achieve the objectives, 5) compatibility of data collection method with the research topic, 6) quality of relationship between the researcher and participants, 7) quality of ethical considerations, 8) accuracy in data analysis, 9) stating of findings clearly, and 10) research value. Then, the final articles were evaluated based on parameters including authors, year of production, research topic, objective, method, analysis and findings via comparative appraisals (Sandelowski & Barroso, 2007). Based on Critical Appraisal Skills Programme (2018), quality of the articles was evaluated and scored. This method has been performed for all final articles that were studied in research background. Frequency of articles with an excellent score (41-20) was 87 percent and with a very good score (31-40) was 13 percent that showed the quality of final articles.

3. Results and Discussion

In line with Sandelowski and Barroso's method (2007), findings of the final articles were analyzed using taxonomic analysis approach that includes inductive analysis through open, axial and selective coding. This method is led to recognition of concepts that provide the ground for extraction of categories. Thus, phrases related to the sugarcane industry were first extracted in the form of initial codes that were the same total stages of production cycle in the sugarcane industry including "process of planting", "process of growing", "process of harvesting" and "process of processing". Then, the initial codes were identified in the form of concepts that indicate the existing pattern in findings via open coding as sub-components. In the end, the sub-components were classified to distinguish semantic relations via axial coding as components and then dimensions. Table 3 shows the identified dimensions and components as well as resources and frequency of sub-components.

Table 3. Open and axial coding of extracted data

	Dimensions	Components	Resources
Model of process innovation in sugarcane industry	Innovation in the process of planting	Precision agriculture technologies	Sira & Pukala (2020); Gorgodze et al. (2022); Solomon et al. (2022)
		Seed technology	Silva et al. (2019); Almukhambetova et al. (2017); Verma et al. (2022)
		Agricultural chemistry innovation	Medennikov (2023); Gorgodze et al. (2022); Munyoro & Tyorera (2023)
		Sustainable planting methods	Medennikov (2023); Gorgodze et al. (2022); Vali Eidy (2015)
		Weather resistant planting techniques	Furtado et al. (2011); Vali Eidy (2015)
		Data-oriented decision making	Gutiérrez Cano et al. (2023); Lay et al. (2022); Park & Kang (2016); Andreini et al. (2022)
		Automation in planting	Furtado et al. (2011); Almukhambetova et al. (2017)
		Joint research initiatives	Sadiki & Lebailly (2021); Andreini et al. (2022)
		Water management innovations	Silva et al. (2019); Klimczuk-Kochańska & Klimczuk (2019); Munyoro & Tyorera (2023)
		Biological pest control	Almukhambetova et al. (2017); Gorgodze et al. (2022)
		Adoption of vertical farming	Sira & Pukala (2020); Almukhambetova et al. (2017)
		Monitoring and policy effect	Klimczuk-Kochańska & Klimczuk (2019); Andreini et al. (2022); Munyoro & Tyorera (2023)
	Innovation in the process of growing	Nutrient management strategies	Sadiki & Lebailly (2021); Vali Eidy (2015)
		Smart irrigation systems	Almukhambetova et al. (2017); Munyoro & Tyorera (2023)
		Climate smart agricultural practices	Furtado et al. (2011); Gorgodze et al. (2022)
		Data-driven product monitoring	Capitanio et al. (2010); Jin et al. (2019); Park & Kang (2016); Dawid et al. (2021)
		Biotechnology for product improvement	Klimczuk-Kochańska & Klimczuk (2019)
		Integrated pest management	Almukhambetova et al. (2017); Munyoro & Tyorera (2023)
		Crop rotation and farming	Almukhambetova et al. (2017); Munyoro & Tyorera (2023)
		Carbon separation methods	Medennikov (2023); Almukhambetova et al. (2017)
		Remote measurement technologies	Stampfl (2016); Lay et al. (2022); Schallmo et al. (2018)
		Comparative cropping calendars	Sadiki & Lebailly (2021); Almukhambetova et al. (2017)
		Knowledge transfer initiatives	Gutiérrez Cano et al. (2023); Masuda (2019); Aliasghar et al. (2020)
		Mechanization in crop conservation	Sira & Pukala (2020); Dawid et al. (2021)
		Mechanical harvesting technologies	Munyoro & Tyorera (2023); Verma et al. (2022)
		Real-time harvest monitoring	Lendel et al. (2015); Medennikov (2023); Gorgodze et al. (2022); Solomon et al. (2022)
		Innovative harvesting techniques	Silva et al. (2019); Gorgodze et al. (2022); Solomon et al. (2022)
		Automation in harvesting	Medennikov (2023); Verma et al. (2022); Solomon et al. (2022)

Innovation in the process of harvesting	Crop residue management	Klimczuk-Kochańska & Klimczuk (2019)
	Quality control measures	Munyoro & Tyorera (2023); Maier, (2018)
	Energy efficient harvesting practices	Sira & Pukala (2020); Vali Eidy (2015)
	Optimization of harvest logistics	Carrijo et al. (2015); Masuda (2019); Vali Eidy (2015)
	Post-harvest technologies	Knierim et al. (2015); Furtado et al. (2011)
	Equipment maintenance innovations	Capitanio et al. (2010); Maier (2018); Sjödin et al. (2018)
	Waste to energy conversion initiatives	Khodadad-Saryazdi (2022); Nayeri et al. (2021)
	Advanced extraction technologies	Lay et al. (2022); Vali Eidi (2015)
	Energy efficient processing plants	Khodadad-Saryazdi (2022); Sjödin et al. (2018); Solomon et al. (2022)
	Automation and robotics in processing	Maier (2018); Sjödin et al. (2018); Nayeri et al. (2021)
	Waste use strategies	Carrijo et al. (2015); Nayeri et al. (2021)
Innovation in the process of processing	Water recycling and conservation	Furtado et al. (2011); Munyoro & Tyorera (2023); Vali Eidi (2015)
	Sustainable packaging innovation	Maier (2018); Medennikov (2023); Vali Eidi (2015)
	Quality control systems	Medennikov (2023); Schallmo et al. (2018); Park & Kang (2016)
	Digitalization of processing operations	Sira & Pukala (2020); Lendel et al. (2015); Medennikov (2023); Müller & Däschle (2018); Solomon et al. (2022)
	Continuous improvement initiatives	Carrijo et al. (2015); Lendel et al. (2015); Aliasghar et al. (2020)
	Joint research in processing	Stampfl (2016); Schallmo et al. (2018); Müller & Däschle (2018)

Based on Table 3, four factors and 45 components were identified. Dimensions of the process-based innovation model in sugarcane industry included "innovation in the process of planting", "innovation in the process of growing", "innovation in the process of harvesting" and "innovation in the process of processing". Accordingly, the effective factors and components on process innovations in sugarcane industry were presented according to Figure 2.

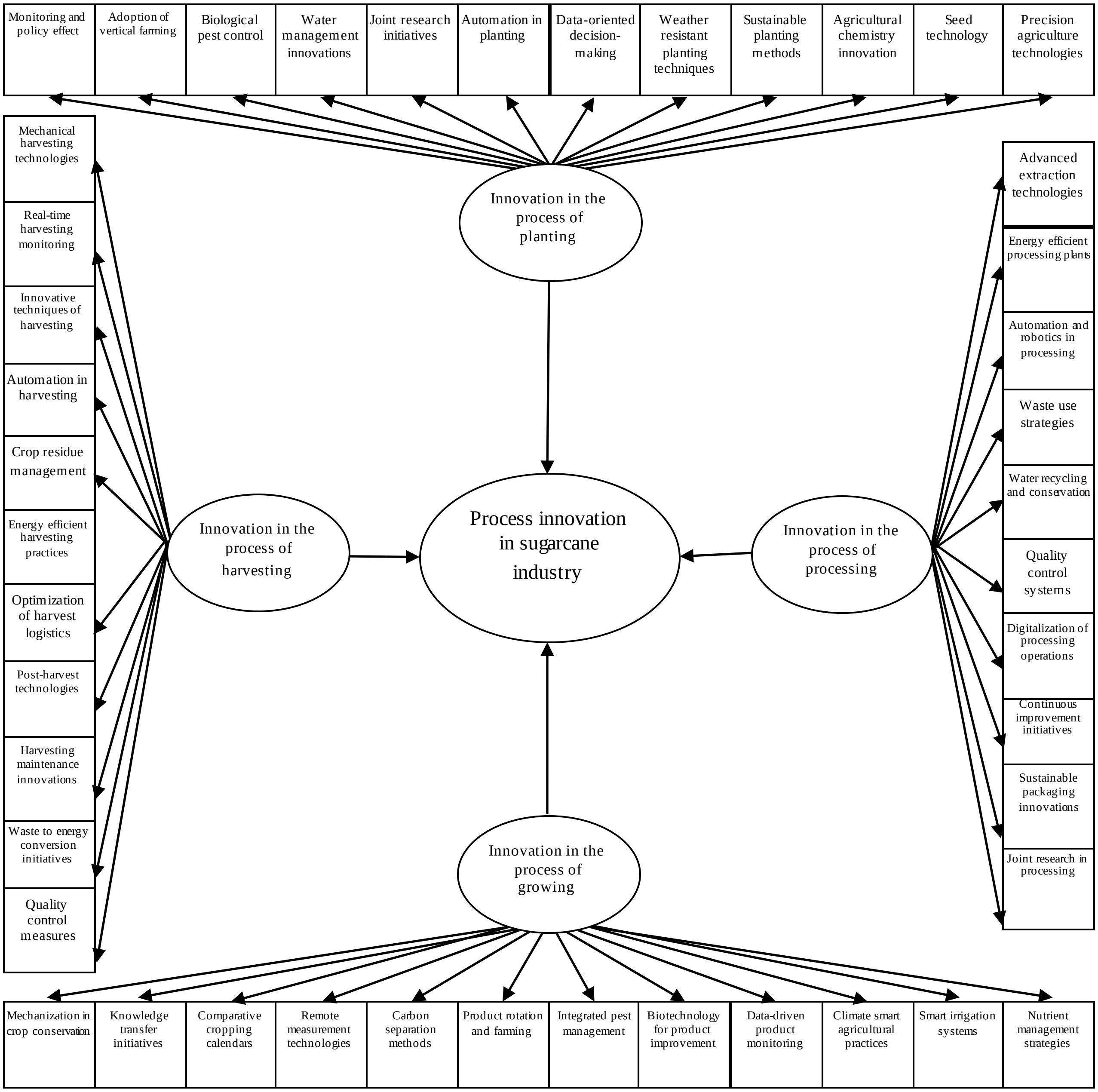

Figure 2. The effective factors and components on process innovation in sugarcane industry

4. Conclusion and Recommendations

This study began to address the considerable research gap in sugarcane industry, namely lack of comprehensive discovery in effective dimensions and components on process innovation. Sugarcane sector has a major role in both global and biological sweetener markets and faces evolving challenges of sustainability, efficiency and technological progress. Importance of the present study has been in its potential for filling the gap in the current literature by presenting meta-synthesis of diverse studies. This study has been conducted via complexities of process innovation in planting, growing, harvesting and processing stages with the aim of proposing valuable insights for stakeholders, policymakers and researchers to enhance total productivity, efficiency and resilience of this industry. By means of meta-synthesis in this research, totally 4 factors involving "innovation in the process of planting", "innovation in the process of growing", "innovation in the process of harvesting" and "innovation in the process of processing" in the form of 45 components have been identified as the effective factors on process innovation in sugarcane industry. Below, each dimension will be explained.

"Innovation in the process of planting" deals with complex network of the effective components on initial stage of sugarcane planting. Precision agriculture technologies are appeared as a building block, incorporating GPS guided equipment and sensor networks. This component originates from Sira and Pukala (2020), Gorgodze et al. (2022) and Solomon et al.'s studies (2022) that embosses the changing effect of precision agriculture on planting accuracy and optimization of resources.

"Innovation in the process of growing" is uncovered as a multi-dimensional research in components that redefine the growth phase of sugarcane planting. Accurate application of nutrients, controlled fertilizers, vegetation species with efficient nutrients, soil health management and fertilization systems constitute the nutrient management strategies. This component is consistent with Sadiki and Lebailly (2021) and Vali Eidi's studies (2015).

"Innovation in the process of harvesting" addresses aspects which redefine the important stage of harvesting in sugarcane planting. Each component is appeared as a vital element and helps better understanding of technology, monitoring and sustainability practices that form the process of harvesting. Sugarcane harvesting machines, harvesting combines, robotic harvesting machines, automatic sugarcane cutters, and mechanized harvesting systems determine the component of mechanical harvesting technologies that are consistent with Munyoro and Tyorera (2023) and Verma et al.'s research (2022) and specify the changing effect of mechanization on efficiency of harvesting.

"Innovation in the process of processing" uncovers complexities that redefine the processing stage of sugarcane planting. High pressure extraction methods, Enzyme-assisted extraction, advanced filtration systems, Ultrasound-assisted extraction, and new extraction solvents show advanced extraction technologies which is consistent with Lay et al.'s research (2022) that specified the changing effect of advanced extraction methods.

The meta-synthesis in this study has presented a comprehensive search of the effective dimensions and components on processing innovation in sugarcane industry. With explaining the planting, growing, harvesting and processing processes, this has not only identified the key factors but also places them in a more extensive field of global agriculture. Dimensions reveal a complex interaction of technological progresses, sustainable methods and joint initiatives that form the path of sugarcane industry.

As this section contains challenges and opportunities, these results provide a map for stakeholders who are looking for reinforcing of innovation, increasing of sustainability and helping evolution of this vital industry. While the present research proposes valuable insights about the effective dimensions and components on processing innovation in sugarcane industry, it is necessary to accept its special limitations. First, relying on the current literature may lead to ignoring the emerging trends in this field. The rapidly changing nature of technology and agricultural methods makes newer progresses possible. Moreover, focusing on sugarcane may limit generalization of the findings to other products or industries.

To address such limitations and help more comprehensive understanding of process innovation in sugarcane industry, future research attempts can adopt a longitudinal approach. Long-term studies that trace evolution of process innovations across time represent a dynamic approach about the processes and transformations. Putting emphasis on multi-method approach, including case studies, opinion polls and interviews can propose a more accurate search of the effective factors on innovation. Besides, exploring the socio-economic effects and consequences of these innovations on local communities, farmers and industry stakeholders enriches the research perspective. Finally, interdisciplinary cooperation that combines insights of agricultural sciences, economy and political studies can represent a more comprehensive viewpoint about challenges and opportunities in sugarcane process innovation.

Recommendations:

To promote process innovation in the sugarcane industry by focusing on the identified factors, the following practical suggestions can be made:

1- Innovation in planting process

•Investing in research to find and breed improved varieties of sugarcane with more favorable characteristics (such as resistance to pests and diseases).

•Use of new technologies such as GPS and soil sensors to optimize the place of cultivation and manage water resources.

•Holding workshops and training courses for farmers in order to learn new planting methods and optimal use of production inputs.

2- Innovation was in the process

•Development of pest management programs using biological and mechanical methods instead of chemical poisons.

•Applying drip and smart irrigation systems to reduce water consumption and increase productivity.

•Creating software and applications for optimal monitoring and management of sugarcane growth process and needs.

3- Innovation in the harvesting process

•Investing in automatic and semi-automatic machinery and equipment for sugarcane harvesting, which increases speed and reduces costs.

•Data analysis to determine the best harvest time in order to maximize product quality and quantity.

•Training the workforce in the optimal use of harvesting equipment and machinery and ways to reduce damage to the product.

4- Innovation in the processing process

•Investing in research to optimize sugar production processes and minimize waste.

•The use of low-energy and low-energy techniques and processes in order to reduce the environmental effects of processing.

•Creating programs to recover and reuse the waste from sugarcane processing as raw materials for the production of other products.

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