

# INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH

2024, Vol. 5, No. 6, 2325 – 2333

<http://dx.doi.org/10.11594/ijmaber.05.06.32>

---

## Research Article

### Accounting Information System and Environmental Uncertainty among Agri-Related Cooperatives in Davao del Norte

Cristen Ge P. Baguio, Frances Joy M. Idul, Maria Ella M. Llemit, Joe Mari N. Flores\*

Department of Accounting Education, University of Mindanao Tagum College, 8106, Philippines

---

#### Article history:

Submission June 2024

Revised June 2024

Accepted June 2024

#### \*Corresponding author:

E-mail:

[joemari\\_flores@umindanao.edu.ph](mailto:joemari_flores@umindanao.edu.ph)

#### ABSTRACT

The primary purpose of this study was to explore the relationship between the variables covered in this study - the Accounting Information System and environmental uncertainty among agri-related cooperatives- and provide personal knowledge and a framework for the contingency theory. The research advocates that most entities need to modernize their business operations due to the emergence of technological advances to support organizational change and decision-making. The study's findings aim to benefit agri-related cooperatives, such as the Board of Directors, the Management, the Entrepreneurs, and future researchers seeking insights. The study focused on agri-related cooperatives in Davao del Norte, targeting accountants or bookkeepers. The selection of respondents was made in a complete enumeration involving seventy-four (74) respondents for the survey as per the data provided by the Cooperative Development Authority. The methodology aims for more reliable insights into the Accounting Information System and environmental uncertainty representing the agri-related cooperative sector. The findings indicate that adequately using a reliable Accounting Information System helps businesses deal with uncertainties. However, the greater the likelihood of environmental uncertainty, the greater the possibility that the Accounting Information System is unlikely to capture operational issues useful for decision-making. Thus, this study concludes that the Agri-related cooperatives in Davao del Norte are highly uncertain, and the usage of the Accounting Information system did not significantly affect the decision-making process.

**Keywords:** *Accounting information system, Environmental uncertainty, Agri-related cooperatives, Tagum City, Davao del Norte*

---

#### How to cite:

Baguio, C. G. P., Idul, F. J. M., Llemit, M. E. M., & Flores, J. M. N. (2024). Accounting Information System and Environmental Uncertainty among Agri-Related Cooperatives in Davao del Norte. *International Journal of Multidisciplinary: Applied Business and Education Research*. 5(6), 2325 – 2333. doi: 10.11594/ijmaber.05.06.32

## Introduction

Globally, the COVID-19 pandemic has severely impacted business entities, facing different issues inside and outside the organization. These problems revolve around environmental uncertainty, including dynamism, volatility, and heterogeneity (Pires & Alves 2022), and are progressing changes, particularly in the consumer industry. Also, the COVID-19 epidemic is throwing enterprises off balance by causing significant changes in customer behavior, supply chains, and courses to showcase (Tao, Sun, Liu, Tian 7 Zhang 2022)

In the Philippines, numerous businesses are not responsive to innovations - may it be in culture, business models, or information systems, which is why businesses face challenges in business innovation, including required workforce, production and services, planning, and modification to regulations (PricewaterhouseCoopers [PwC] 2022).

In dealing with unprecedented events, many decision-makers question the reliability of information due to the unpredictability of environmental conditions (Lodge & Boin 2020, as cited in Pirez & Alvez 2022, para. 1). As market risk and uncertainty rise, investors and company owners become more risk averse, relying upon essential data while eliminating other information deemed irrelevant and hypothetical. Hence, during the COVID-19 pandemic, the credibility of accounting information in accounting records and audit reports has become progressively crucial to investors and markets, and conditional conservatism in accounting has dealt with this gap (Cui et al. 2021). Making decisions during such circumstances where information is confusing and conflicting is crucial. Hence, it is necessary to implement a new response in such a complex and volatile time for a business to make better decisions (Aon, 2020, as cited in Pires et al., 2022). It also highlighted the necessity for leaders to advance the implementation of efficient working techniques and changes in the value chain to aid in outwitting uncertainty (Thuan et al. 2022).

There were existing studies regarding the effectiveness of accounting information under environmental uncertainty; however, these studies did not emphasize agri-related cooperatives. One of these studies was the study of

Pires & Alves (2022). This study investigated the relationships between the efficiency of AIS and management accounting practices (MAPs) used in manufacturing companies operating in Portugal under environmental uncertainty. Moreover, this study has yet to have any existing studies within the Philippines that strictly deal with the Influence of environmental uncertainty on the usage of accounting information systems. The broad scope and highly uncertain environment of the agri-related cooperatives in Davao del Norte prompt the researchers to pursue this research, further study the variables used, establish the relationship between accounting information systems and environmental uncertainty, and provide insight to different organizations, particularly in the consumer industry.

## Research Objectives

This study determines if the company's Accounting Information Systems are appropriate for the Environmental Uncertainty among Agri-related Cooperatives in Davao del Norte.

Specifically, the study seeks an answer to the following objectives: To assess the level of Accounting Information Systems among Agri-related Cooperatives in Davao del Norte regarding System quality, Information quality, and System threats. To assess the level of environmental uncertainty among agri-related cooperatives in Davao del Norte in terms of dynamic, environmental heterogeneity, and environmental hostility. To assess the significant relationship between Accounting Information Systems and Environmental Uncertainty among Agri-related Cooperatives in Davao del Norte. Lastly, the domain of accounting information systems that influence environmental uncertainty must be determined.

## Hypothesis

The following study hypotheses were examined at a 0.05 significance level, revealing no significant relationship between the Accounting Information System and Environmental Uncertainty in Agri-related Cooperatives. No domain in the Accounting Information System significantly influences the Environmental Uncertainty of Agri-related Cooperatives.

## Methods

This chapter covers the research methods that the researchers will apply in the study. It includes the research design, locale, population and sample, research instrument, data gathering procedure, and statistical tool.

### Research Design

This quantitative research utilizes a correlational type of research design. By definition, correlational research involves assessing two (2) variables and investigating relationships between variables without controlling or manipulating any of them. It may be either a positive or negative result. (Devi et al. 2022). Moreover, this type provides insights into relationships and helps researchers develop theories and forecast events (Bhandari 2023). The process of gathering the data is based on the adopted-modified research questionnaire. These questionnaires will collect data from the target respondents, develop theories, and form conclusions. Moreover, this study focuses on determining the Influence of the AIS on Environmental Uncertainty among the Agri-related Cooperatives in Davao del Norte.

### Research Locale

The findings of this study are specific to the context of agri-related cooperatives in Davao del Norte. The results of this study are limited by the scope and the sample used by the researchers. Accordingly, even though there could be standard features to other related studies, the findings could differ depending on the scope and context of the study.

Davao del Norte's province is between 7°33'42.37" north latitude and 125°39'11.83" east longitude. It is composed of ten (10) municipalities, two-hundred and twenty-three (223) barangays comprising seventy-four (74) Agri-related cooperatives that are compliant with the standards. Furthermore, the scope of this study is delimited to Agri-related cooperatives in Davao del Norte, Philippines.

### Population and Sample

The researchers utilized complete enumeration to select the study's respondents. This technique involves all individuals within a

sampling unit as the sample of the study. Therefore, all agri-related cooperatives within Davao del Norte are part of the scope of this study.

Moreover, the researchers selected respondents with specific characteristics connected to the study (Dudovskiy 2024). In this study, the respondents must be a compliant Agri-related cooperative operating the Accounting Information System for at least one (1) year. The selected bookkeepers or accountants of the agri-related cooperatives responded to the survey questionnaire to obtain more reliable and accurate data essential for the study.

The selection of respondents should be in a complete enumeration involving all Agri-related Cooperatives in Davao del Norte. Each respondent must be an agri-related cooperative with one (1) bookkeeper or accountant to answer the questionnaire. In this study, the researchers aimed to survey a maximum of seventy-four (74) respondents based on data from the Cooperative Development Authority (CDA). Furthermore, a recommended response rate from 50% to 80% provides greater credibility to survey results (Beehr et al. 2022).

### Research and Sample

This study utilizes the research-made questionnaire as a gathering tool for this study. These questionnaires are adapted from Burgos et al. (2022) for the independent variable and Pires et al. (2022) for the dependent variable. The items were made simple and on a Likert scale for the ease of the respondents. The adapted and modified research questionnaire consists of three (3) sections. Section A describes the Demographic Features of the respondents as the Gender, years of cooperative existence, operation of a business, and the size of the cooperatives; Section B set of questionnaires refers to the Accounting Information System among Agri-related Cooperatives in Davao del Norte with three (3) indicators namely; System Quality, Information Quality, and System Threats.; The Section C set of questionnaires focuses on Environmental uncertainty, with three (3) indicators: Dynamism, Environmental Heterogeneity, and Environmental Hospitality.

## Result and Discussion

This chapter presented the research study's data and findings regarding whether the company's accounting information systems are appropriate when agri-related cooperatives are under environmental uncertainties.

RO1: Level of Accounting Information Systems among Agri-related Cooperatives in Davao del Norte

Table 1 shows the level of the AIS. As shown in the table, it accumulates an overall mean of 3.57, indicating a high descriptive level and an SD of 0.29, which implies that AIS is highly effective in agri-related cooperatives in Davao

del Norte. The higher respondent rating across all variables could indicate the reason for the high level. The respondents' responses to the survey indicated that AIS among Agri-related cooperatives in Davao objected to the idea under system threats.

The presented overall mean score was generated based on the descending order of computed mean scores as follows: 4.47, indicating a very high level for information quality with an SD of 0.44; 4.41, signifying a very high level for system quality with an SD of 0.45; and 2.04 denoting a low level for system threats with an SD 0.44.

Table 1. Level of Accounting Information Systems among Agri-related Cooperatives in Davao del Norte

Indicator	Mean	SD	Descriptive Level
<b>System Quality</b>	4.41	0.45	Very High
<b>Information Quality</b>	4.47	0.44	Very High
<b>System Threat</b>	2.04	0.44	Low
<b>Overall</b>	<b>3.57</b>	<b>0.29</b>	<b>High</b>

The responses relating to the level of AIS were high, which implies that the Accounting Information Systems of agri-related cooperatives were highly effective, gathering a range of means equal to 3.57 and a standard deviation of 0.29. Burgos et al. (2022) supported the study's result regarding the level of AIS. It implies that adopting and utilizing accounting information systems provides more efficiency for the organization, improving overall business operations. Hence, Thuan et al. (2022) further suggest that organizations should consider efficient working techniques by implementing appropriate information systems.

The indicator System Quality, which had a range of means of 4.41 and a standard deviation of 0.45, had an agreeable rating of very high under AIS. The accounting information system level was very high in terms of system quality, which means that the quality of accounting information systems among agri-related cooperatives positively impacts the company. It indicates that an accounting information system is efficient as it reduces programming errors, consolidates reporting operations of various existing business divisions, provides ease of use to meet users'

requirements, and has secure data retrieval and storage. The AIS is reliable, and the response time is fast. Furthermore, Akil (2023) further suggests that adopting AIS to the organization adds value to the firm through better managerial decisions and effective internal control and enhances the financial and non-financial performance of the business entity.

In furtherance, information quality had a range of means of 4.47 with an SD of 0.44, which has a descriptive definition that is very high in AIS. Under Information system quality, the assessment revealed a notably high level of AIS. It indicates a positive evaluation of the information quality within the accounting information system utilized by Agri-related cooperatives. It implies that the AIS of the Agri-related cooperatives is compelling enough to produce relevant, complete, and timely valuable information for decision-making, protects confidential data from unauthorized access, creates helpful knowledge for future references, and is compelling enough to produce accurate information. Moreover, Thuan & Thu Huong (2019), further imply that maintaining and improving the AIS of the company significantly affects its competitive edge - including its organizational

goals and performance. It positively impacts the entity's value by promoting its organizational commitment and delivering quality information - leading to an effective and efficient organizational structure.

Lastly, System Threats had a range of means of 2.04 with an SD of 0.44, having a descriptive definition and a low rating regarding AIS usage. It indicated that the AIS under system threat was adverse. It proves that the AIS of agri-related cooperatives is secure in terms of data storage, retrieval, and protection. The company does not frequently experience unauthorized access by unauthorized personnel, system failure, prohibition of data transmission to remote locations, or the creation of fictitious financial reports. Users in the organization do not use the same password. Some accounting information systems require 24/7 internet access. The results imply that agri-related cooperatives have robust security and system control strategies. Otherwise, ignorance of these threats to AIS could negatively affect the business organization. Moreover, Lutfi (2023) states that adequate internal control is crucial

for the organization to reduce or lessen the negative impact of the AIS risks, thus providing more relevant information for the organization's success.

RO2: Level of Impact of Environmental Uncertainty among Agri-related Cooperatives in Davao del Norte.

Table 2 shows the Level of Impact of Environmental Uncertainty. As shown in the table, it had an overall mean of 3.93, indicating a high descriptive level with an SD of 0.50.

The cited overall mean score was the result derived from the following computed mean scores from highest to lowest: 4.20 or high for environmental heterogeneity with an SD of 0.61; 3.89 or high for environmental hostility with an SD of 0.60; and 3.83 or high for dynamism with an SD of 0.63. The high level was attributed to the high rating given by the respondents in all indicators. The respondents' responses indicated that environmental uncertainty among agri-related cooperatives in Davao del Norte was highly observed regarding dynamism, environmental heterogeneity, and environmental hostility.

Table 2. Level of Environmental Uncertainty among Agri-related Cooperatives in Davao del Norte

Indicator	Mean	SD	Descriptive Level
<b>Dynamism</b>	3.83	0.63	High
<b>Environmental Heterogeneity</b>	4.20	0.61	High
<b>Environmental Hostility</b>	3.89	0.60	High
<b>Overall</b>	<b>3.93</b>	<b>0.50</b>	<b>High</b>

The level of environmental uncertainty had a mean of 3.93, with an SD of 0.5 and a descriptive level of high. The result implies that all measures described under the environmental uncertainty evaluation of Agri-related cooperatives were high. The study's result corresponds with the work of Zayadin et al. (2022), which states that uncertainty affects entrepreneurial activity at different levels. It could be in the form of ineffective communication to consumers, a reduction of supplies and production due to changes in customers' buying habits, a decrease in purchasing power, stagnating markets, and the inability of customers to invest in their long-term projects, which eventually results to the downfall of the business organization, if not addressed properly and effectively.

The indicator, Environmental Heterogeneity, had a high descriptive level, which means that environmental heterogeneity was highly observed. It indicates that the environmental heterogeneity in environmental uncertainty among agri-related cooperatives is considerably diverse in areas like competition, customers' buying habits, and product lines. Accordingly, Tao et al. (2022) state that uniqueness and diversifiability in any organization profoundly impact business set-up; hence, companies must respond rapidly and adapt their strategies based on perceived uncertainty.

Similarly, the respondents had an agreeable rating of high on Environmental Hostility. Regarding environmental hostility, the level of environmental uncertainty among Agri-related

cooperatives was highly observed. The results indicate that Agri-related cooperatives in Davao del Norte have a robust competitive environment that threatens the quality of their products, labor supply, and materials. Moreover, this sector is centralized by legal and political matters, experienced economic constraints, and has to deal with different environmental and social responsibility requirements. The result implies that agri-related cooperatives are more prone to a hostile environment. Govindan (2021) states that implementing inappropriate framing and unsupportive procedures could negatively influence business operations and social sustainability. Hence, organizations should integrate stakeholders, business processes, technology, politics, and other institutions in business practice.

Lastly, the Dynamism result indicated that the environmental uncertainty level was high. This shows that the respondents need help to predict what the competitors will do next and when the product demand changes. The research and development of the organization are very intense; the products offered for consumer consumption become obsolete quickly, and product technologies change very quickly. The result states that the agri-related sector is dynamic and more prone to unpredictable

changes. Thus, there are several studies demonstrating that entrepreneurial practices such as willingness to take risks, innovative thinking, being proactive, autonomy, and aggressive competitor behavior have a beneficial impact on earnings, share of the market, growth, and overall success of the business. (Ireland et al., 2006; Hameed, 2011; Morched, S. & Jarboui, A. (2021).)

**RO3: Significance of the Relationship between Accounting Information Systems and Environmental Uncertainty**

This study assesses the significant relationship between the accounting information system and environmental uncertainty in Davao del Norte Agri-related cooperatives. Pearson r was used to ascertain the correlation between the two variables. The comprehensive findings are presented in Table 3.

The research findings revealed that the AIS versus Environmental Uncertainty yields an R-value of 0.173, indicating no significance between the two variables. The result was traceable to the significance level of 0.05, lower than the p-value of 0.171. It resulted in the decision to accept the null hypothesis, which stated that there is no significant relationship between accounting information systems and environmental uncertainty.

*Table 3. Significance of the Relationship between Accounting Information Systems and Environmental Uncertainty among Agri-related Cooperatives in Davao del Norte*

Variables	Mean	SD	r-value	p-value
<b>Accounting Information System</b>	3.57	0.29	0.173	0.171
<b>Environmental Uncertainty</b>	3.93	0.50		

\*Significant at 0.05 significance level

**Conclusion**

The research findings on the relationship between AIS and Environmental Uncertainty show that the AIS had no significant effect on Environmental Uncertainty. This result corresponds to Zayadin et al. (2022) work, in which the impact of high uncertainty, ambiguity, time pressure, and emotional intensity on business decision-making remains under-theorized. This means that when uncertainty arises, financial information does not help navigate the organization's problems nor help eliminate the

business risks and negative impacts. Masicotte & Henri (2021, as cited in Pires et al., 2022) further suggest that organizations should consider financial and non-financial information and other related factors for effective decision-making and efficient business operations (p. 2). Furthermore, the precision of any elements and the ability of the entrepreneur to adapt their behavior under uncertainty are under-contested (McMullen & Shepherd 2006; Magnani & Zucchella 2018; Zayadin et al., 2022).

In effect, AIS and EU have no significant relationship in the agri-related cooperative sector, contrary to other related studies of contingency theory (Pires et al. 2022), and requires further studies and pieces of evidence to conclude that AIS and EU have a significant relationship.

## Recommendations

In response to the results and discussions, the following recommendations were offered:

1. **For Agri-related Cooperatives Board of Directors and the Management:** This study suggests that relying on financial and non-financial information would be better to avoid and lessen the impact of environmental uncertainties on the company. Focusing more on the effectiveness of AIS and other technological aspects has moderate to no effect under such circumstances. It indicates that uncertainties are broad; the greater the likelihood of environmental uncertainties, the greater the possibility that the AIS is unlikely to capture operational issues and company concerns useful for decision-making. Therefore, companies should improve their judgments and professional behavior under perceived uncertainties.
2. **For Entrepreneurs:** This study suggests that entrepreneurs exposed to greater risks of uncertainties must widen their scope in determining the different sources of unpredictability and their impact on business operations.
3. **For Future Researchers:** This study would provide future researchers an avenue to study further the variables covered in the study.

## Acknowledgment

We extend our sincerest gratitude to the following for extending their mental, practical, and spiritual guidance, support, and invaluable assistance in making this study successful. The researchers express their deepest thanks particularly to:

**University of Mindanao Tagum College**, thank you for providing your support and tremendous effort to help us finish this study and for allowing this study to be known to the public interest.

**Jimnanie A. Manigo, DBA**, and **Jovit G. Cain, CPA, MSA**, panel members, for sharing their time and knowledge in checking and making corrections that improved our study.

**Ronnie F. Garcia**, statistician, for his guidance, patience, and effort in helping with the data needed in our study.

Most significantly, we thank **Joe Mari N. Flores, CPA, MSA**, research adviser, and program head, for his patience and encouragement throughout our studies. His technical advice was necessary for the completion of this study.

To the Dean of College, **Dr. Gina Fe G. Israel, Ed. D.** thank you for approving the letters needed to complete this study.

To the **Cooperative Development Authority (CDA) Region XI Extension Office and staff**, we are thankful for the effort in offering to help us get the data needed for the study.

In recognition of the assistance from our supporters, we sincerely acknowledge the following:

To our **friends**, thank you for making this journey bearable. We highly appreciate your presence, unconditional love, and unending support.

To our **family**, thank you for providing moral, spiritual, and financial support and materials for this project.

Above all, we thank our **Almighty God**, the servant king, for his guidance, knowledge, and wisdom, which made our study possible.

## References

- A Pires, R. and Alves, M.-C.G. (2022), The impact of environmental uncertainty on accounting information relevance and performance: A contingency approach. *Economics*, 10(9), p. 211. <https://doi.org/10.3390/economics10090211>
- Akil N (2023) Positive correlation between accounting information system and organization's performance-in depth review of literature. ResearchGate. DOI:10.13140/RG.2.2.21618.99523
- Bhandari P (2023) Correlational research: When & how to use. Scribbr. <https://www.scribbr.com/methodology/correlational-research/>
- Burgos C, Namoc I, Padilla J & Flores JM (2022) The influence of accounting information

- system on the organizational performance among SMEs in Tagum City. *International Journal of Multidisciplinary: Applied Business and Education Research*, 3(5), pp. 781–790. <https://doi.org/10.11594/ijma-ber.03.05.06>
- Decision making in complex & volatile times. Retrieved from [\[https://www.aon.com/get-media/68d39f7a-cec7-4795-b3a7-3558d77ecff7/Decision-Making-in-Complex-and-Volatile-Times-Keys-to-Managing-COVID-19\]](https://www.aon.com/get-media/68d39f7a-cec7-4795-b3a7-3558d77ecff7/Decision-Making-in-Complex-and-Volatile-Times-Keys-to-Managing-COVID-19)
- Devi, R, Pradhan, S, Giri, D, Lepcha, N and Basnet, S (2022) Application of correlational research design in nursing and medical research. *Journal of Xi'an Shiyou University, Natural Sciences Edition*, 65(11), pp.60-69. DOI <https://doi.org/10.17605/OSF.IO/YRZ68>
- Dudovskiy J (2024) *The Ultimate Guide to Writing a Dissertation in Business Studies: A Step-by-Step Assistance*. 7th edition. Business Research Methodology.
- Beehr, T, Kim, M, & Armstrong, I (2022) How much do survey response rates affect relationships among variables? *International Journal of Social Research Methodology*, 27(1), pp. 63–86. DOI: <https://doi.org/10.1080/13645579.2022.2113663>
- Govindan, K., Shaw, M. and Majumdar, A. (2020) Social sustainability tensions in multi-tier supply chain: A systematic literature review towards conceptual framework development, *Journal of Cleaner Production*. DOI: <https://doi.org/10.1016/j.jclepro.2020.123075>
- Lutfi, A (2023), Factors affecting the success of accounting information system from the lens of Delone and McLean is model. *International Journal of Information Management Data Insights*. DOI: <https://doi.org/10.1016/j.jjime.2023.100202>
- Massicotte, S and Henri JF (2021) The use of management accounting information by boards of directors to oversee strategy implementation. *The British Accounting Review* 53: 100953. DOI: <https://doi.org/10.1016/j.bar.2020.100953>
- Morched, S. & Jarboui, A. (2021). Does Entrepreneurship Dictate the Profitability Growth of Firms? (Evidence from France). *Journal of Business and Entrepreneurship*, 9(1), 78-94. Retrieved from <https://ojs.sampoernauniversity.ac.id/index.php/IOBE/article/view/156>
- PricewaterhouseCoopers 2020, Innovation and digital transformation: How are Philippine MSMEs performing?: Business Unusual, PwC. Retrieved from <https://www.pwc.com/ph/en/publications/ph-columns/business-unusual/2020/innovation-and-digital-transformation-how-are-philippine-msmes-performing.html>.
- Tao H, Sun X, Liu X, Tian J and Zhang D (2022) The Impact of Consumer Purchase Behavior Changes on the Business Model Design of Consumer Services Companies Over the Course of COVID-19. *Front. Psychol.* 13:818845. <https://doi.org/10.3389/fpsyg.2022.818845>
- Thuan, L.D. and Thu Huong, T.T. (2019) Organizational Factors and Quality of Accounting Information System in Vietnam. *Global Journal Al-Thaqafah* Volume 9, Issue 1, 2019, pp.2232 – 0474. Retrieved from <http://www.gjat.my/gjat072019/GJAT072019-4.pdf>
- Thuan, PQ, Khuong, NV, Anh, NDC, Hanh, NTX, Thi, VHA, Tram, TNB & Han, CG (2022), The determinants of the usage of accounting information systems toward operational efficiency in Industrial Revolution 4.0: Evidence from an emerging economy. *Economies*, 10(4), p. 83. Retrieved from <https://doi.org/10.3390/economies10040083>
- Zayadin, R, Zucchella, A, Anand, A, Jones, P, (2022) Entrepreneurs decisions in perceived environmental uncertainty. *British Journal of Management* 34, no. 2 (2023): 831-848. DOI: <https://doi.org/10.1016/j.jclepro.2020.123075>