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Enhancing Sustainable Practices in Liberica Coffee Agrobusiness: A Technological Approach

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ABSTRACT

Liberica coffee has gained increasing prominence within Malaysia's speciality coffee landscape due to its unique flavour profile and adaptability. However, most Liberica coffee planters continue to rely on traditional processing methods that limit yield efficiency and undermine environmental sustainability. To address these challenges, this study undertakes a systematic literature review (SLR) to identify and evaluate technological innovations that enhance sustainable practices in Liberica coffee farms. Using the PRISMA 2020 methodology, articles were systematically retrieved from Scopus and Web of Science databases. Search strings were developed using a hybrid AI-guided and expert-validated process to ensure high precision and recall. The initial search yielded 289 articles. After duplicate removal, eligibility screening, and access limitation, 12 articles were selected for full-text analysis. The findings reveal several relevant technologies that hold promise for the Liberica context, including solar drying systems, IoT-based smart agricultural technologies, and AI-assisted operation. Research demonstrates that these technologies can decrease greenhouse gas emissions, enhance resource efficiency, and bolster smallholder income. However, adoption is hindered by high upfront costs, lack of technical know-how, and infrastructural limitations, particularly in rural farming communities. This study adds to the growing body of knowledge about sustainable coffee processing by mapping relevant worldwide technology to Malaysia's Liberica sector. This review sparks ideas for coffee farmers, agrotech developers, and regulators and provides useful advice on how to make Malaysia's coffee business more sustainable, innovative, and competitive.

INTRODUCTION

According to the International Coffee Organization (ICO) report, around 125 million individuals rely on coffee production for their living (International Coffee Organization, 2022). Coffee remains one of the most

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widely consumed beverages, with approximately 3 billion cups consumed daily based on ICO reporting. The number of cups was dominated by two types of coffee species which are Arabica and Robusta. In recent years, a lesser-known but robust coffee species - Liberica, has gained the spotlight in Malaysia's coffee industry. Liberica has been traditionally covered by Arabica and Robusta varieties; nevertheless, due to its peculiar flavour profile and resistance to illnesses, it has become a viable choice for Malaysian coffee planters (Lachenmeier et al., 2022). As a result of a Malaysian-grown Liberica coffee winning awards at the World Barista Championship 2021, the global recognition of Liberica was significantly enhanced, highlighting the potential of the Liberica species as a speciality coffee (Karmen, 2022).

Through the course of its history, Malaysia's coffee business has mostly concentrated on the Robusta variety, which is preferred due to its higher yields and compatibility with the climate of the nation. Lee & Ruck (2022) highlighted the fact that the third wave in the coffee industry has increased customers' demand for distinctive flavours and environmentally responsible business practices. The Speciality Coffee Association (SCA) has developed a score that improves the value of coffee to another level, which includes Liberica. In the highly competitive global coffee market, the unusual flavour of Liberica, which is frequently characterised as robust and fruity, always presents a lucrative potential for Malaysian producers who are looking to separate themselves from their competitors. Additionally, due to its resilient nature (Hafif et al., 2024; Lachenmeier et al., 2024), it is possible to cultivate it in a wide variety of geographical regions, including low-altitude places that are not appropriate for Arabica planting. The reemergence of Liberica in Malaysia is supported by synchronised research and development initiatives focused on enhancing cultivation and post-harvest methodologies. The Malaysian Agricultural Research and Development Institute (MARDI) has created ten varieties of Liberica, with both public and commercial partners advocating for sustainable growing and processing procedures adapted to local conditions (MARDI, 2023). These approaches aim to improve product quality and consistency while minimising environmental effect, a progressively vital concern in global agriculture discussions.

Despite this progress, the technological dimensions of sustainable Liberica coffee processing remain significantly underexplored. While a substantial body of literature exists on Arabica and Robusta (97.4%), there is a lack of consolidated knowledge regarding applicable processing technologies and their sustainability impacts for Liberica (1.1%), as reviewed by Rendón-Mera et al. (2022). The above data shows a lack of reliable references for industries, governments and agencies seeking to promote sustainability and competitiveness in Malaysia’s speciality coffee sector. Therefore, this systematic literature review (SLR) is being conducted to synthesise cross-disciplinary evidence, identify globally tested innovations, and assess their relevance to Malaysia’s Liberica context. Such an approach supports evidence-based practice and contributes to sustainable development goals (SDG), including SDG 12 (responsible production and consumption) and SDG 13 (climate action), by spotlighting agrotech solutions that reduce environmental footprints and promote social and economic resilience (United Nations, 2025). This review is guided by three key objectives:

(i) To map technological innovations applied in sustainable coffee processing worldwide.
(ii) To assess the environmental, social, and economic impacts of these technologies.
(iii) To identify common implementation challenges and evaluate their transferability to the Malaysian Liberica context.

METHODOLOGY

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria to enhance the quality and validity of its design and the recommendations provided in this article. To streamline the systematic review process, the first articles were acquired from the Scopus database, which is managed by Elsevier, and followed by the Web of Science (WOS) database, which is managed by Clarivate. We deem all selected databases appropriate for use because we have used them in several

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systematic studies across various disciplines. All the databases chosen offer a significant assortment of literature that scholars can use as valuable resources in this research. The literature search for the current review used targeted keywords to narrow down the results and concentrate on the relevant subject matter. The process of obtaining the final assessment reports followed the PRISMA 2020 flow diagram (Page et al., 2021), as shown in Figure 1, in line with the protocol for "identifying new studies through databases and registers”.

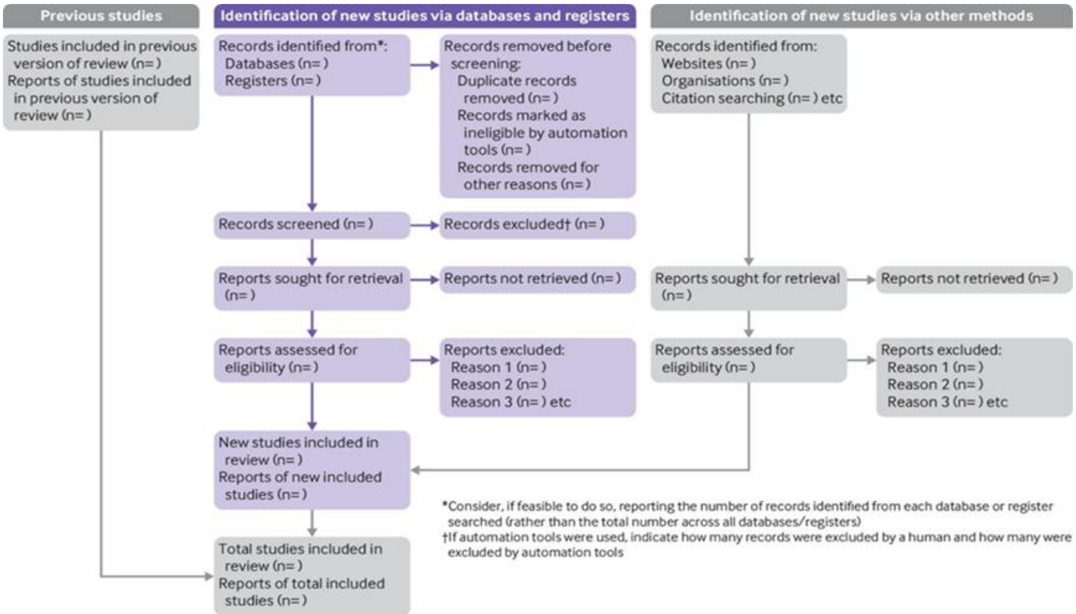

Fig. 1 *PRISMA 2020 flow diagram template for systematic reviews.*

Formulation of research objectives

This paper uses the PICO framework (Methley et al., 2014) as a tool to formulate research questions and establish research objectives. This tool assists researchers in developing objectives that are suitable for the review. The tool consists of four main components, specifically Population, Intervention, Comparison, and Outcome (PICO). Table 1 displays the identified components necessary for the development of the paper's firm objectives, as determined by the researcher.

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Table 1. *Research Question Development Tools (PICO)*

Population (P)	Malaysia's Liberica coffee industry
Intervention (I)	Implementation of technological innovations
Comparison (C)	Traditional processing methods
Outcome (O)	Improvement in environmental, social, and economic

Based on Table 1 above, this study has come out with this research question: "What is the impact of technological innovations compared to traditional methods on the environmental, social, and economic aspects of Liberica coffee industry players?" To answer this question, we propose several search strings on all the databases discussed earlier. The keyword search string for all the databases presented in Table 2.

Table 2. *Search Strings from Scopus and WOS*

Database	Search Strings	Result
SCOPUS	TITLE-ABS-KEY (coffee OR "Liberica coffee") AND TITLE-ABS-KEY (sustainable OR "green technology" OR eco OR "environmental impact" OR "energy efficiency") AND TITLE-ABS-KEY (technology OR innovation OR "renewable energy" OR IoT OR automation OR "waste management")) AND PUBYEAR > 2015 AND PUBYEAR > 2015 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "MULT")) AND (LIMIT-TO (OA , "all")	138 documents
WOS	TS=(coffee OR "Liberica coffee") AND TS=(processing OR fermentation OR drying OR roasting OR milling) AND TS=(sustainable OR "green technology" OR "environmental impact" OR "energy efficiency" OR eco) AND TS=(technology OR innovation OR "renewable energy" OR IoT OR automation OR "waste management") Refine by: Languages=(English) AND Document Types=(Article) AND Timespan=(2015–2025)	151 documents

Data collection and screening

The above-mentioned search instituted a total of 289 research studies from both Scopus and Web of Science (WOS). The collected literature is then evaluated to see if it is good enough for further reporting and analysis. The next phase of analysis and discussion was carried out after all the publications were transferred to workable software (Microsoft Excel) for data organisation and screening. Thereafter, the data was screened by four reviewers focusing on the research title, abstract, and keywords. This process is guided by applying several eligibility criteria to filter and obtain appropriate articles. The criteria for the records are as follows: (1) they must incorporate research studies specifically focused on implementation of technology in farming, (2) the variable of interest should be improvement in sustainability, and (3) the population of study should be the Liberica coffee or coffee industry. The data gathered from WOS and Scopus have duplication that needs to be removed.

Quality appraisal

The quality appraisal stage was done to make sure that documents being chosen were of excellent quality. The Appraisal tool for Cross-Sectional Studies (AXIS) by Downes et al. (2016) helps us figure out how good cross-sectional studies were and detect any biases that might affect how valid the results are. This guarantees that the SLR only includes papers with excellent methodological quality and a low risk of bias, which makes the review's results more reliable and trustworthy. For the final part of this evaluation, about 12 publications were chosen for data abstraction and analysis.

Data extraction and analysis

The current study employed a qualitative methodology. The researcher meticulously analysed the 12 articles, focusing specifically on the abstract, findings, and discussion parts. The data abstraction was

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executed in accordance with the research questions, indicating that any data from the examined studies capable of addressing the research questions were extracted and organised in a table. Afterward, the researcher conducted thematic analysis that determined themes and sub-themes through the identification of patterns, clustering, quantification, recognition of similarities, and relationships present within the abstracted data. According to Flemming et al. (2019), thematic analysis is the method that is deemed to be the most appropriate for producing a synthesis of an integrated mixed study design. In conducting thematic analysis, Mohamed Shaffril et al. (2020) proposed to start with the themes. Themes were the process of identifying the patterns from the article being collected. Any similar content was joined together into a group. The author and co-author built a structured data extraction matrix with columns for the author, year, geographic focus, technology mentioned, reported sustainability implications, and implementation issues. The data were subjected to thematic coding to discern predominant technological groupings and overarching sustainability themes.

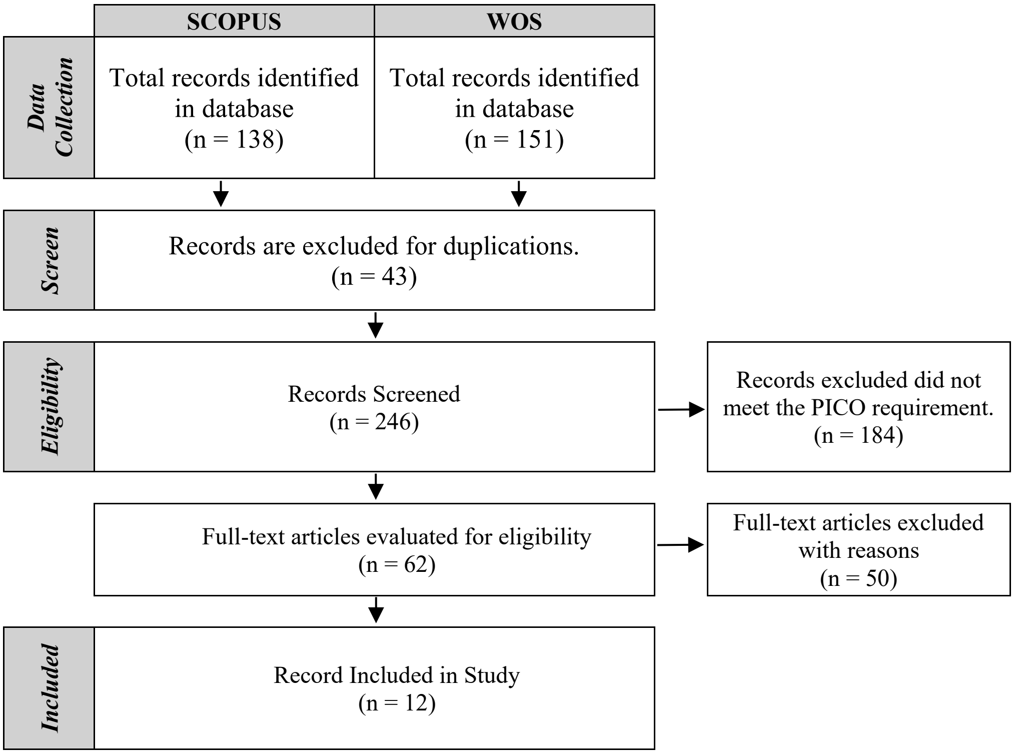

Fig. 2 *Source Selection Flow Chart*

RESULTS

Background of the selected articles

The review managed to obtain 12 selected articles. Based on the thematic analysis, three themes were developed namely Energy Efficiency, Quality Preservation and Automation & Precision (Table 3). Among the 12 selected articles, Brazil emerged as the predominant location for coffee research, represented by 5 studies, followed by Ethiopia with 2 articles, while Colombia, Vietnam, and Mexico each contributed 1 study (Figure 3). There are two studies that do not specify any country in their research. All the studied

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countries were coffee bean producers for the coffee industry. Out of 12 selected articles, one paper each was published in 2019, 2020, 2023 and 2025; three papers in 2024; and five papers were published in 2022.

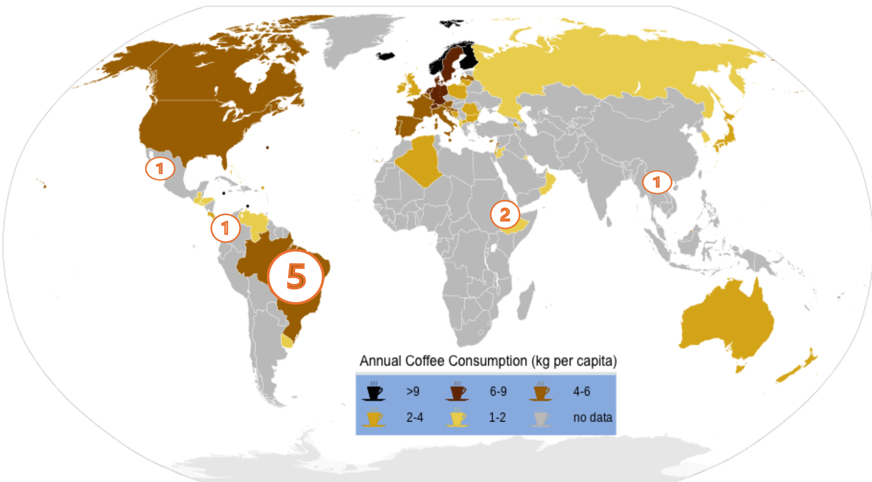
Table 3

Articles Themes Formulation.

Studies	Regions	Energy Efficiency	Quality Preservation	Automation & Precision
Eron et al. (2023)	Brazil			/
De Carvalho et al. (2024)	Brazil		/	
Contreras-Medina et al. (2019)	Mexico			/
Huang et al. (2020)	N/S		/	
Konopatzki et al. (2022)	Brazil	/		
Rodriguez-Pabon et al. (2022)	Colombia	/		
Diro et al. (2022)	Ethiopia			/
Soares et al. (2022)	Brazil		/	
Ho et al. (2022)	Vietnam	/		
Thai et al. (2024)	Ethiopia		/	
Iqbal et al. (2024)	Brazil	/		
Rashid et al. (2025)	N/S			/

Figure 3

Articles Distribution Based on Country



Note: This photo created by authors for the research

Energy efficiency

Energy efficiency means getting the most out of something (such as crop production or processing quality) while using the least amount of energy possible through improved technology or processes. It cuts down on waste, lowers carbon footprints, and makes the economy more viable by lowering operational expenses, as discussed in the study by Ho et al. (2022), Iqbal et al. (2024), Konopatzki et al. (2022), and Rodriguez-Pabon et al. (2022). The implementation of Internet of Things (IoT) devices in coffee farms for monitoring purposes demonstrated an enhancement in coffee bean yield; nevertheless, it also resulted in increased

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energy consumption by the devices. Consequently, a study by Rodriguez-Pabon et al. (2022) proposed an adaptive sample period methodology to mitigate energy usage. Ho et al. (2022) discovered that advanced irrigation technology employed in coffee farms aids in water conservation and enhances efficiency, while Iqbal et al. (2024) propose the utilisation of a solar system for coffee pulping, which enhances energy efficiency and assists small coffee farmers in reducing petrol expenses for electric generators.

Quality preservation

Quality preservation is using technologies and methods that keep or improve the taste, smell, feel, and chemical properties of coffee beans during production and processing. Speciality Coffee Association (SCA) quality standards have become a major guiding principle for many coffee farmers. These standards include requirements for reduced bean defects, environmental sustainability, and fair-trade practices, all of which directly enhance the economic value of their coffee. In the early stage of producing good coffee cherries, early disease detection with unmanned aerial vehicle (UAV) multispectral imaging may help farmers in detecting coffee tree leaf rust before they can see it, allowing them to take focused action to stop quality losses on the plant (Soares et al., 2022). After that, a real-time vision system, like a convolutional neural network that sorts green beans from camera frames, helps get rid of defective beans before roasting them. This technology cuts down on human error and makes grading more stable, which keeps the quality of the cup (Huang et al., 2020). A mobile and web-based deep learning program that diagnoses nine types of defects in real time helps keep quality control consistent during sorting and reduce waste from each coffee batch (Thai et al., 2024). After reducing the defect from the bean, a controlled drying technology, such as a mechanical dryer that uses dehydrated air, makes moisture removal more consistent. By using a mechanical dryer, it may help reduce bean defects and enhance the quality of beans from traditional yard drying. This keeps the beans intact and makes the drink taste better, which is good for business due to high SCA points (Konopatzki et al., 2022).

Automation and precision

All industries are developing and exploring automation to enhance productivity, cut costs, and improve product quality. This is also being adopted in the agricultural industry, especially the coffee sector. Employing Artificial Intelligence (AI), sensors, and UAVs are used to save resources and keep quality consistent (Rashid et al., 2025). A computer vision model used in a mobile app for farmers checks the ripeness of fruit before it is picked, guesses the yield and quality, and works with UAV scouting to improve watering and fertilisation. This automates monitoring and also improves precision in time for coffee harvest (Eron et al. 2023b). The precision harvest time may help the yield of coffee production. Contreras-Medina et al. (2019), in their study, suggested a roadmap for indigenous coffee producers to incorporate precise tools such as sensor modules for humidity, lighting in greenhouses, electrochemical and optical sensors for early disease detection, remote sensing and spectroscopy for soil evaluation, and a greenhouse solar dryer to expedite drying while safeguarding coffee cherries. A climate-smart agricultural (CSA) technology, discussed by Diro et al. (2022), shows that technology education and information sharing using technology among the coffee planters in that area are improving the coffee production precision.

DISCUSSION

This review puts together evidence on technology that makes the coffee value chain more sustainable, and then it explains what the results represent for Liberica agrobusiness. Most studies look upon Arabica or mixed systems, but the same ideas work for Liberica as long as they are adapted to the local environment, canopy, and processing standards.

Digital monitoring and decision support clearly help with timing and resource use. A recent review talks about how AI, IoT, and UAVs work together to obtain real-time data on crop conditions, make

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predictions, and automate actions that make irrigation, pest management, and field operations better while having less of an impact on the environment (Rashid et al., 2025). Computer vision on mobile devices makes this a part of everyday life. A model built inside a mobile CoffeeApp got a mAP@0.5 of 0.89 and was used to estimate yield and plan when to harvest. It could also help with scheduling irrigation and fertiliser in precision systems (Eron et al., 2023). For Liberica estates and smallholders, these techniques help keep picking windows consistent and cut down on lost inputs. Even though all the positive outcomes are being produced, several limitations on the farmer side are also being discussed. Rashid et al. (2025) highlighted in their study that limited cargo capacity to bring on the UAV may reduce the number of sensors that are useful for more accurate data collection. Besides that, they also have a problem with the unfriendly weather when operating the UAV.

UAVs are also being used to give early illness surveillance, which makes it possible to use fewer chemicals and more targeted ones. UAV multispectral imaging detected coffee leaf rust as early as 15 days post-inoculation utilising a support vector machines (SVM) classifier, achieving 80% accuracy and moderate concordance. The authors contend that this permits fungicide application solely when necessary(Soares et al., 2022). However, their study addresses the challenge of collecting high-quality photographs with the UAV under specific conditions. Only photos taken between 11:00 AM and 1:00 PM are deemed reliable for data analysis. Other studies need to come up with more advanced image-capturing technology, which also incurs more cost to the farmer.

The sensing technology in detecting plant health becomes a limitation in the actual world. An adaptive sampling strategy for on-farm IoT device current draw by roughly 11% while keeping the quality of humidity and temperature data high on a real coffee farm (Rodriguez-Pabon et al., 2022). The same study says that the average energy current drop across testing is 10.88%, and it also says that device variance and gearbox are the main uses of energy. Those adaptive schedules help battery life and cut down on maintenance rounds for Liberica farmers where nodes are far from grid power. Despite the assistance in enhancing energy efficiency for IoT devices, these devices must also be more cost-effective, particularly considering the economic circumstances of small and medium-sized farmers. Researchers should concentrate on developing more cost-effective IoT devices that also prioritise energy efficiency.

Energy efficiency, previously discussed, is a significant environmental concern that also encompasses water usage on farms. A meta-frontier study conducted by Ho et al. (2022) involving 896 Vietnamese farms indicates that, on average, irrigation water efficiency is suboptimal. Just taking part in the certification programme didn't make any difference in water efficiency. Advanced systems, especially sprinklers, worked better than micro-basin approaches, and windbreaks were linked to better results based on Ho et al. (2022). They added that certification programmes need to include water-saving technologies in order to make a difference. Technology such as sprinkler irrigation is proving useful for Liberica farming, which commonly thrives in Southeast Asia's lowland areas with high evaporation rates. However, their study (Ho et al., 2022) also indicated that elevation has a significant influence on the effectiveness of this sprinkle technique, as higher elevations are positively correlated with water efficiency.

Nutrient efficiency comes into play as an important contributor to both farm producers' yield and runoff. Field studies with controlled-release NPK nutrient technology have shown enhanced growth responses and elevated yields compared to traditional formulations as doses rose, suggesting superior alignment with plant demand over time (De Carvalho et al., 2024). For Liberica, when the canopy is strong and the internodes are long, persistent fertiliser delivery can help prevent flush-and-leach cycles, lessen the number of applications, and cut down on losses during heavy rains. The technology of controlled nutrient release is a breakthrough, but it is only being conducted in a controlled environment. The technology still needs a field test in small, medium and large-scale coffee farms to investigate the efficiency and effectiveness of this technology.

Post-harvest coffee bean technology is helping in increasing the bean quality and price. Drying with dehumidified air instead of concrete yards resulted in fewer cracked and faulty beans, better retention on

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screen 17, and a price premium of 12.11% in a study done by Konopatzki et al. (2022). They suggested a satisfactory economic return, with a discounted payback period of 2.27 years and a stated return of 2.49 million US dollars under the modelled scenarios. Scenario analysis done by Konopatzki et al. (2022) demonstrated that viability is influenced by sale price, electricity tariffs, and borrowing rates; however, it remained appealing across the examined ranges. This is important for Liberica, since cup scores go up when drying is even and gradual enough to keep the fermentation from going too far.

AI can speed up quality control, but there are certain trade-offs. An experiment done by Thai et al. (2024) showed a real-time data pipeline sorted nine types of defects in 1 to 3 seconds per stream, making it easy to quickly sort items in warehouses and on the go. They added that systems with more defect classes had lower average accuracy than systems with fewer defect classes. However, they stressed that fast feedback was better for sorting lines. For Liberica grading, these tools (AI Bean Defect Detection Application) help sort out seeds that aren't ripe yet or have been damaged by insects before they are stored or sent. This makes the seeds more uniform and increases the quality of the coffee beans being sold.

The technology of using renewable energy for processing solves the problems of fuel costs and emissions. A motor pulper powered by solar energy could handle about 783 kg of coffee beans per hour at 467 rpm. Iqbal et al. (2024) proposed a 1103.64-watt motor with an inverter, two batteries, and a charge controller that were all sized to the local insolation. Specifications and bench testing explain how much torque, power, and safety margins are needed for field deployment, as well as how well the parts work together. This lowers the need for diesel during cherry peaks and cuts down on pulping downtime for off-grid Liberica facilities. As Malaysia is a prominent global hub for photovoltaic module manufacture, media reported that Malaysia is in third place worldwide, with a capacity of around 23.6 GW (Sudarshan Varadhan, 2024). The report also highlights that the low price of solar may help Liberica farmers to use the technology.

In Ethiopia's coffee systems, the adoption rates for climate-smart practices like fertiliser, low cultivation, intercropping, and physical soil and water measures were between 19 and 47% (Contreras-Medina et al., 2019). Bwiza et al. (2024) stated that education, exposure to extension services, and access to telecommunication technology substantially enhanced the adoption of climate-smart agriculture. Their research identified complementarities among practices, indicating that the adoption of one practice enhances the probability of adopting further practices. This shows that Liberica communities need to work together to reach out to people, using communication technology that fits with how people in those areas use the media. Communicating effective practices, such as climate-smart agriculture, has become a policy that governments and industry stakeholders must incorporate into their plans, especially for Liberica farmers in Malaysia.

Putting these data together gives us a useful stack for Liberica coffee agrobusiness: Use adaptive IoT nodes for microclimate and soil moisture to make devices last longer and cut down on service trips. Use UAV scouting to look for stress and early signs of rust, and then use this information to aim sprays and protect the canopy. When possible, switch to and reduce evaporation (Ho et al., 2022; Rodriguez-Pabon et al., 2022; Soares et al., 2022). Use controlled-release fertilisers to ensure that nutrients are always available, even when it rains heavily (De Carvalho et al., 2024). Implement power pulping using solar energy in areas where the electrical grid is unreliable, and upgrade the drying process from open yards to dehumidified air to ensure stable moisture removal and achieve quality premiums (Iqbal et al., 2024; Konopatzki et al., 2022). Use mobile computer vision technologies for pre-export sorting and field yield estimation to make logistics and labour planning more efficient (Eron et al., 2023; Thai et al., 2024). Farmers need to be trained, extension services need to be in sync, and radio or mobile channels need to be easy to access so that people can learn (Diro et al., 2022).

It is evident what the limitations are and what study is needed. Most agronomic experiments and AI models were created in Arabica regions or mixed contexts. To work with Liberica, they need to be adjusted for the variable canopy structure, berry size, and pulp chemistry. The economic viability of dehumidified

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drying is contingent upon local electricity tariffs and construction expenditures. Reported defect-classification speeds are high, but accuracy varied with the number of classes. This means that datasets specific to Liberica flaws should be created (Konopatzki et al., 2022; Thai et al., 2024). Future research will evaluate adoption strategies via extension and radio programming (Diro et al., 2022; Ho et al., 2022).

One message comes up over and over in the studies we looked at: Combine AI and sensors with focused field measures to increase post-harvest control and ensure that technology distribution goes hand in hand with farmer help. By doing this, Liberica agrobusiness can increase quality, lower the impact on the environment, and make more money along the chain (Rashid et al., 2025).

RECOMMENDATION

This study proposed various recommendations for future scholars' consideration. First, we recommend more research needs to be done on the Liberica coffee species (1.1%), as many studies focus on the Arabica species (70.2%), which has been revealed by Rendón-Mera et al. (2022) in their study. This systematic review reveals that future research should consider examining integrated technology rather than standalone technologies, such as a mechanical dryer that uses dehydrated air (Konopatzki et al., 2022), which may not be applicable to all coffee farm conditions. Multi-site, randomised, or quasi-experimental trials of adaptive IoT sensors and related agricultural technologies in both dry and wet conditions, particularly in Malaysia, will enhance farmers' comprehension of the implications of utilising these technologies. Additionally, developing an AI model that focuses specifically on Liberica coffee is essential, as this species has a different characteristic that may not have been captured in prior research. Given the proliferation of technology, it is crucial for future research to examine the use of this technology across small, medium, and large-scale coffee farms. Each coffee farm scale may have different outcomes and challenges to face when implementing this technology.

CONCLUSION

This systematic review compiled international evidence regarding technological methods to improve sustainability in coffee farming, with repercussions for the Malaysian Coffee Liberica sector. We looked at 12 peer-reviewed studies spanning 2015 to 2025 in two major academic databases: SCOPUS and Web of Science. The investigation indicated that energy efficiency, quality preservation and automation are some of the most important and well-studied emerging technologies in coffee processing. These technologies help protect the environment, make operations more efficient, and improve social conditions in coffee-growing areas. But their use is nonetheless limited by capital insufficiency, a lack of technical know-how, government support and gaps in structural regulations, especially in developing countries and smallholder-driven industries like Malaysia's Liberica. To resolve these problems, the industry and government need to work together, build and guide expertise in certain areas, and conduct technology experiments in specific situations. This review points out important areas of knowledge and gaps in the implementation of the technologies. It provides researchers, policymakers, and industry personnel with a plan for how to make the Malaysian Liberica coffee business more sustainable and profitable. Future empirical research in Malaysia should emphasise field trials, economic feasibility evaluations, and policy coherence to convert these global best practices into implementable local solutions.

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Conflict of Interest

The authors agree that this research was conducted in the absence of any self-benefits or commercial or financial conflicts and declare the absence of conflicting interests with the funders.

Author Contributions

Rashid Salleh came up with the idea and researched the issue. Dr. Norhamizan Hamir developed and oversaw the protocol. They created the search strategy, executed database searches, and managed and duplicated records. Data screening was conducted by Ahmad Hidayat Ahmad Ridzuan, Ashraf Siddik Khan Abdul Rahim Siddiqe and Rashid Salleh, while Dr. Norhamizan Hamir settled any disputes. Data extraction and analysis are being developed by all the authors in this research. Each author assessed quality and risk of bias using specific criteria. The project supervisor was Dr. Norhamizan Hamir, and all authors authorised the final version.

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