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Farming for the Future: Exploring the Possible Practices of Low-Carbon Farming in Mitigating Climate Change in Malaysia

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ABSTRACT

The agricultural sector plays a significant role in climate change as a major contributor to greenhouse gas emissions. Given agriculture's vulnerability to climate variations, shifts in seasons, and extreme weather, global productivity and yields are at risk. To address both climate change and food security, promoting low-carbon farming practices is crucial. These practices aim to reduce greenhouse gas emissions, minimize agricultural carbon footprints, enhance resilience, and foster sustainable agricultural development. This narrative review paper aims to examine low-carbon agricultural practices, drawing on literature reviews and recent research on climate vulnerabilities. It explores significant practices that can help mitigate climate change by transitioning to perennial crops, implementing plant factories, and promoting healthy diets. The discussion includes challenges to adopting the practices and suggests ways to overcome them, along with government policies in Malaysia supporting low-carbon farming, particularly for small-scale farmers. Future research should focus on exploring Malaysia's existing technological infrastructure that supports low-carbon agricultural practices.

Keywords: Low-carbon farming, Climate change, Carbon footprint, Greenhouse gas emissions, Agriculture

INTRODUCTION

Climate change is one of the most pressing global challenges of our time, with far-reaching impacts on ecosystems, economies, and human well-being. Climate change refers to the long-term alteration of temperature and typical weather patterns in a specific location (Shivanna, 2022). Agriculture is particularly vulnerable to the impacts of climate change due to its inherent dependence on climatic factors for effective operation and productivity (Agovino *et al*., 2018). In 2020, agriculture accounted for approximately 12.3% of global greenhouse gas emissions (World Resources Institute, 2022). In the United States, agriculture accounts for about 11% of global greenhouse gas emissions from economic activities and electricity consumption (Environmental Protection Agency, 2020). Similarly, in Europe, the agricultural sector contributes to approximately 10% of the total greenhouse gas emissions within the European Union (EU) (McMahon & Cardwell, 2015). Contrastingly, Malaysia experienced a significant increase in greenhouse gas emissions from the agricultural sector, rising by 35% from 2000 to 2011 (Ahmad *et al*., 2018). Specifically, emissions from agricultural production accounted for 11.8% of global greenhouse gas emissions and 8.22% of Malaysia's greenhouse gas emissions in 2016 (Ridzuan *et al*., 2020). The vulnerability of the agricultural sector to climate change puts food security at risk, particularly for vulnerable communities and developing countries. Agriculture is extremely vulnerable to these climatic changes. In most regions of the world, productivity and yields are likely to suffer from shifting seasons and heightened weather variability (Fan and Ramirez, 2012; Lemi, 2019).

At the same time, to address the dual challenges of climate change mitigation and food security, it is crucial to promote low-carbon farming practices. Low-carbon farming can be defined as a set of agricultural practices that aim to minimize greenhouse gas emissions and reduce the carbon footprint of farming activities (Borychowski *et al.*, 2022; Hou and Hou, 2019; Jiang *et al.*, 2022). Utilizing low-carbon farming techniques can be pivotal in mitigating the effects of climate change on agriculture, strengthening agricultural resilience, and promoting sustainable and healthy agricultural development (Ling *et al*., 2022). By adopting these practices, they would not only benefit farmers and agricultural communities but also contribute to global food security.

This narrative review paper comprehensively explores low-carbon agricultural practices aimed at reducing greenhouse gas emissions. It evaluates the effects of these practices and investigates agricultural and economic policies linked to adapting agriculture to climate change. Drawing from literature reviews and recent research on climate-induced vulnerabilities, the paper also examines obstacles to mitigating climate change and suggests ways to overcome them. This study aims to provide useful information for policymakers and utilizes existing literature to address uncertainties in economic analysis.

LOW-CARBON FARMING PRACTICES IN MITIGATING CLIMATE CHANGE

Low-carbon farming practices encompass various techniques such as agroforestry, conservation tillage, crop rotation, and the utilization of organic fertilizers and cover crops (Avasiloaiei *et al*., 2023). Implementing low-carbon farming practices can significantly contribute to climate change mitigation by sequestering carbon in soil and biomass, reducing the need for synthetic fertilizers and pesticides, and promoting biodiversity in agricultural landscapes. Low-carbon farming practices not only reduce greenhouse gas emissions but also have numerous co-benefits that contribute to sustainable agriculture and food security. The following are low-carbon agricultural practices that can help mitigate the impacts of greenhouse gases:

Perennial crops

One key low-carbon farming practice is the shift toward perennial crop development and cultivation. Perennial crops have the potential to drastically reduce the carbon footprint of agriculture (Bužinskienė *et al*., 2023). Perennial crops, with their extensive root systems, have the ability to sequester carbon in the soil for prolonged periods. This process aids in reducing greenhouse gas emissions and mitigating climate change (Hong *et al*., 2020; Leisner, 2020). Additionally, perennial crops are more efficient in their utilization of water and nutrients, reducing the dependency on external inputs and minimizing the risks of soil erosion and nutrient leaching. It also promotes healthy soil (Chapman *et al*., 2022) and reduces the need for synthetic fertilizers and pesticides. This not only benefits the environment by preventing chemical runoff into waterways but also contributes to the overall sustainability of agricultural practices (DeHaan, 2015; Li & Huang, 2023; Zhang *et al.*, 2011). Perennial crops also provide benefits beyond carbon sequestration and soil health. They can provide a more stable and reliable source of income for farmers (Danso-Abbeam *et al*., 2023), as they demand less yearly labor and resources compared to annual crops. This can lead to more resilient and sustainable agricultural systems, particularly in response to unpredictable weather patterns and changing climatic conditions.

Cultivating perennial crops not only enhances sustainability and climate resilience but also supports biodiversity by providing a stable and diverse habitat for wildlife (Radzikowski *et al.*, 2020; Zhang *et al*., 2011). Cultivation of staple food like rice, corn, and cassava plays a dominant role in Malaysia's agricultural industry. These crops contribute to food security, stimulate rural development, and generate employment opportunities. Among all staple foods, rice, as one of the most important staple crops, provides a major source of energy and protein for nearly half of the world's population (Schneider & Asch, 2020; Sen et al., 2020). In Malaysia, rice cultivation has a long history and remains a vital agricultural activity. Additionally, in 2023, Malaysia is the 26th largest producer of rice in the world, with a production capacity of approximately 1,750,000 metric tons (USDA, 2024; World Agricultural Production, 2023). In China, advancements have been made in the cultivation of perennial staple crops, particularly in the development of perennial rice varieties. A prominent example is the Yunda 107, characterized by its high-quality attributes. Yunda 107 exhibits an enhanced yield potential attributed to an increased grain count per panicle and heightened photosynthetic capacity of flag leaves post-full heading (Xiaobo *et al*., 2020). These physiological enhancements facilitate increased accumulation of photosynthetic products, thereby augmenting the biological yield upon reaching maturity. Additionally, other varieties such as PR Yunda 23 (PR23), PR Yunda 25 (PR25), and PR Yunda 107 (PR107) have been authorized and made available for commercial cultivation as perennial crop varieties globally (Guo *et al*., 2023). The promotion of perennial rice cultivation stems from the efficacy of its breeding technology in reducing labor and input costs (Zhang *et al*., 2023). Malaysia could likewise adopt this technology to enhance rice production without exceeding predetermined costs, concurrently promoting perennial crops for low-carbon farming practices.

To fully realize the potential of perennial staple crops for low-carbon farming and climate change mitigation, several steps need to be taken. Firstly, there needs to be increased investment in research and development to develop new perennial cultivars. This includes utilizing advanced breeding techniques and genetic technologies to enhance the traits of perennial staple crops, such as their resilience to climate stress and their productivity. Studies suggest that integrating modern breeding methods, such as CRISPR-Cas9 and genomic selection, with traditional approaches has the potential to improve yield, resilience, and sustainability, thereby ensuring stable food supplies, reducing crop losses, and accelerating breeding processes (Anand *et al*., 2023; Crews and Cattani, 2018). However, while these advanced techniques differ from conventional genetic modification (GMO), public perception and regulatory acceptance of genetic technologies still vary across countries. In some regions, concerns over genetic interventions, including non-GMO approaches like gene editing, may hinder adoption despite their potential benefits for low-carbon agriculture. Secondly, there is a need for policy support and incentives to encourage farmers to transition from annual to perennial staple crop systems. This can include financial incentives, such as subsidies or tax breaks, as well as technical support and training to assist farmers in making the transition. Additionally, efforts should be made to promote knowledge sharing and capacity building among farmers, researchers, and agricultural extension services to ensure the successful adoption of perennial staple crops and sustainable farming practices. By embracing perennial staple crops and transitioning toward low-carbon farming, we can mitigate climate change while simultaneously promoting sustainable agriculture and protecting the environment.

Furthermore, perennial crops can also contribute to the preservation of traditional farming knowledge and practices, as many of these crops have been cultivated for generations and hold cultural significance. By incorporating perennial crops into staple food production systems, Malaysia can ensure the preservation of traditional agricultural practices while meeting the increasing demand for staple foods in the country.

Plant factory

Plant factories have emerged as a promising solution for promoting low-carbon agricultural practices. By utilizing advanced technologies such as artificial lighting, aeroponics, hydroponics, the Internet of Things (IoT), and vertical farming, plant factories can significantly reduce the carbon footprint associated with traditional agriculture (Harbick and Albright, 2016; Nájera *et al*., 2022; Rajaseger *et al*., 2023; Yano *et al*., 2023; R. Zhang *et al*., 2017). While some of these technologies are also used in open-field environments, their integration within plant factories offers additional benefits in reducing emissions. The controlled environment of plant factories allows for precise resource management, minimizing water usage through closed-loop hydroponic and aeroponic systems, optimizing energy consumption with automated IoT-based monitoring, and reducing reliance on chemical inputs. Additionally, vertical farming in plant factories enables higher productivity per unit area, limiting land conversion and mitigating carbon emissions from deforestation.

Furthermore, plant factories can be strategically established in urban areas, minimizing the need for long-distance transportation and thereby reducing emissions associated with supply chains. This localized food production further contributes to lowering the carbon footprint by decreasing transportation-related emissions. Plant factories can incorporate plant genetic diversity and microbial interactions to enhance their environmental sustainability (Shelake *et al*., 2019). By utilizing plant genetic diversity, they can cultivate crops that are more resilient to adverse climates and disease, thereby reducing the reliance on synthetic pesticides or fertilizers (Santiteerakul *et al*., 2020). In addition, integrating microbial interactions can improve nutrient cycling, thereby reducing the reliance on chemical inputs. Plant factories also have the potential to adopt carbon capture models, which can further mitigate greenhouse gas impacts (Chen *et al*., 2024; Zhang *et al*., 2017), but these models have not yet been implemented in commercial plant factories.

While plant factories have been hailed as a solution to many environmental and agricultural challenges, there are opposing arguments that highlight the potential drawbacks of this approach. Critics argue that the heavy reliance on technology in plant factories, particularly artificial lighting, climate control systems, and advanced monitoring, contributes to a significant carbon footprint. According to research findings, the majority of carbon emissions (about 67%) stem from lighting usage. Other processes contribute approximately 15% to these emissions, while infrastructure such as building construction adds up to around 10% (Chen *et al*., 2024). As energy-saving technologies become more widespread with the aim of reducing energy use and emissions, they unintentionally promote more building renovations and potentially increase carbon emissions from construction activities, as supported by other research (Zainordin & Zahra, 2021). Another argument against plant factories is related to their scalability and affordability. Critics argue that plant factories require significant upfront investment due to expenses related to building construction, cultivation systems, machinery, and advanced control systems (Mosaleeyanon, 2022; Zhang *et al*., 2023).

The integration of plant factories into agricultural practices presents a significant opportunity to promote low-carbon, sustainable food production. As technology continues to advance, plant factories are poised to play a crucial role in mitigating the environmental impact of agriculture while meeting the increasing global demand for food. Meanwhile, considering the disadvantages of plant factories is also crucial in understanding the broader implications of embracing them as a predominant model for agricultural production.

Healthy diets

A healthy diet plays a significant role in supporting and driving the adoption of low-carbon farming practices to mitigate the impact of agriculture on climate change while also reducing carbon footprint emissions (Dixon *et al*., 2023; Nabipour Afrouzi *et al*., 2023). By emphasizing the consumption of sustainably produced food, such as fruits, vegetables, legumes, whole grains, nuts, and seeds, individuals can directly contribute to the demand for low-carbon farming methods while supporting their health and the environment. Research has shown that diets such as vegan, climatarian, Mediterranean, and Atlantic diets, which have lower carbon footprints, also bring health benefits to individuals (Dixon *et al*., 2023; Esteve-Llorens *et al*., 2019). Plant-based diets have been shown to have lower carbon footprints compared to diets high in animal products. Dietary recommendations vary worldwide. Some countries, like the United States of America and Thailand, advocate for a mix of plant and animal proteins, while others, such as India, focus solely on plant-based proteins. For example, US vegetarian guidelines promote plant-based foods along with dairy and eggs. These guidelines also differ significantly in their carbon footprints, ranging from 0.86 kg CO_2-eq/d in India to 3.83 kg CO_2-eq/d in the United States (Kovacs *et al*., 2021). Interestingly, the basic US dietary guideline emits over twice the carbon compared to the US vegetarian guideline (Kovacs *et al*., 2021). This idea is further supported by other studies, which suggest that adopting plant-based diets could lead to a substantial decrease in land use (by 76%), greenhouse gas emissions (by 49%), eutrophication (by 49%), and water use (by 21% for green water and 14% for blue water), while also providing significant health benefits (Gibbs & Cappuccio, 2022).

Consuming a healthy diet not only supports personal health but also has a profound impact on the environment (Guasch-Ferré & Willett, 2021). By focusing on consuming fresh, locally sourced produce and minimizing processed and packaged foods, individuals can help minimize the environmental impact of food production and distribution (Nabipour Afrouzi *et al.*, 2023). The research revealed that the Atkins 20 diet model had the most significant adverse environmental impact, emitting 8.74 kg CO_2-eq/per/day in greenhouse gas emissions and consuming 7731 L/day in total water, while the Ornish and Mediterranean diet models showed lower environmental impacts, with greenhouse gas emissions ranging from 2.2 to 3.07 kg CO_2-eq/day and total water footprints ranging from 3184 to 3675 L per day, respectively (Kemaloglu *et al*., 2023). Additional research indicates that opting for plant-based diets may result in lower greenhouse gas emissions (GHGEs), reduced land use, and less biodiversity loss compared to typical diets. However, the effects on water and energy usage may vary depending on the specific types of plant-based foods consumed (Carey *et al.*, 2023). When considering the argument for plant-based healthy diets, it is crucial to evaluate the overall environmental impact of different dietary choices and agricultural practices.

While there are valid points regarding the benefits of animal agriculture, also known as animal husbandry in specific contexts, the global shift toward plant-based diets and sustainable farming methods remains an essential strategy for mitigating greenhouse gas impacts. To address the concerns raised about the potential drawbacks of solely promoting plant-based diets, it is important to emphasize the need for diversified and context-specific approaches to agriculture. Integrating agroecological principles, such as incorporating livestock in rotational grazing systems and optimizing the use of marginal lands for sustainable animal husbandry, can provide a balanced approach that supports both environmental sustainability and food security.

CHALLENGES TO ADOPTING LOW-CARBON FARMING

It is important to consider the potential drawbacks and challenges associated with low-carbon farming practices. The feasibility of these practices depends on financial investment, infrastructure readiness, and farmers' accessibility to technology, which may limit their widespread adoption. Some argue that implementing these practices may require significant technical expertise, which could be a barrier for many small-scale farmers. The researchers revealed that the limited understanding of climate change, low-carbon technologies, and environmental awareness among farmers hampers their recognition of the benefits associated with adopting such technologies, thereby hindering both their intention to adopt and their actual adoption behavior (Jiang *et al*., 2022; Mustafa *et al*., 2019). Moreover, few farmers are aware of climate change. They mainly notice changes in temperature and local weather conditions but are less aware of its other adverse effects, such as rising sea levels, biodiversity instability, and land use constraints (Ado *et al*., 2018; Ng'ombe *et al*., 2020). Farmers have limited knowledge about low-carbon farming techniques and require training to effectively implement these practices on their farms. Therefore, there is a need for research and extension services to provide farmers with information and resources to support the adoption of low-carbon farming. Another effective approach to educate farmers about climate change and low-carbon farming practices is by utilizing media platforms like television, internet, and social media (Hou & Hou, 2019). The media platforms serve as an effective means to reach farmers, especially in rural areas, and promote the objective of mitigating climate change.

Additionally, the initial capital costs associated with transitioning to low-carbon farming methods pose a significant challenge for farmers considering adoption. Research has shown that farmers who heavily rely on income from agriculture tend to be more cautious about investing in new technologies or practices compared to those who are less reliant on agricultural income (Li *et al.*, 2021). Many farmers lack the financial resources to invest in new equipment, technology, or infrastructure needed to implement these practices. The expenses related to the adopting low-carbon farming practices vary depending on factors such as the region's level of industrialization, the farming system employed, and the specific mitigation approach employed; for example, conservation tillage may be more cost-effective in highly industrialized regions, whereas reforestation might be a more economical choice in areas undergoing industrialization (Tang *et al*., 2019). Furthermore, trade-offs exist between environmental benefits and economic practicality (Shao et al., 2022; Sidhoum et al., 2022). For example, plant factories reduce land use and water consumption, and their reliance on artificial lighting and climate control increases energy costs, making them less viable without renewable energy integration. Likewise, transitioning to perennial crops enhances soil carbon sequestration but requires long gestation periods and high upfront costs, which may not be financially feasible for farmers seeking immediate returns.

Also, farmers, especially small-scale farmers, may encounter difficulties in affording the substantial costs associated with transitioning their farming practices. These agricultural practices entail high risks and offer low returns to farmers (Mizik, 2021). One way to address this and assist small-scale farmers financially is by establishing the concept of shareholders, a practice already implemented in China and some Western countries (Tang *et al*., 2019; Woodhill *et al*., 2020). While shareholder involvement can sometimes lead to improved farm management practices and decision-making through expertise or access to resources, this method can be quite risky for farmers (O'Connell & Ward, 2020; Opitz *et al*., 2019; Srebro *et al*., 2021). They may lose control over their operations and face pressure to prioritize short-term profits over long-term sustainability (O'Connell & Ward, 2020). However, shareholders offer a key advantage over profit sharing, which is risk mitigation and access to capital. Shareholders have a vested interest in the farm's success and are often willing to provide upfront capital for improvements or share financial burdens during difficult times. This financial security can allow farmers to focus on long-term planning and sustainable practices that benefit the farm in the long run.

Most of the world's food production comes from small-scale farmers' crop production, especially in developing countries (Mizik, 2021). The majority of small-scale farmers are elderly, and age has emerged as a significant challenge in the adoption of new agricultural technology and practices (Ntshangase *et al*., 2018; Tamirat *et al*., 2018). Previous research suggests that younger farmers are more inclined to adopt organic farming practices than the elderly. Additionally, demographic groups such as female landowners, individuals with higher education levels, farm owners, and those with additional off-farm income show a greater propensity towards embracing organic farming (Sapbamrer & Thammachai, 2021). This contrasts with findings from a study conducted in the Kapurthala district of Punjab. Farmers aged 20–30 years showed higher engagement in training sessions, demonstrations, and field visits, resulting in greater knowledge acquisition than those over 40 years old. However, older farmers exhibited greater adoption of various management practices compared to younger ones (Sharma, 2016). The suggested approach to resolve this issue involves older farmers transferring their agricultural land to younger successors for further expansion and development.

RELATED POLICIES AND GOVERNMENT SUPPORT IN MALAYSIA

Within the context of Malaysia's status as a developing nation, examining the impacts and challenges associated with low-carbon farming practices underscores the recognition of similar issues within the country. Consequently, Malaysia has implemented several policy and regulatory frameworks aimed at supporting and incentivizing the adoption of sustainable agricultural practices. The government has recognized the upward trajectory in greenhouse gas emissions, prompting the implementation of the National Agri-Food Policy 2.0 (NAP 2.0) (MAFS, 2021a). NAP 2.0 aims to enhance agricultural productivity and harvest quality by leveraging technological advancements and innovative practices. Furthermore, the National Food Security Policy Action Plan 2021-2025 outlines the government's strategies to support the established policy, with a focus on expanding technology development based on climate mitigation (MAFS, 2021b). The government has instituted financial aid initiatives and subsidies, such as the Young Agropreneur Program to aid farmers in procuring essential infrastructure and technology for low-carbon farming, aiming to mitigate climate change (MAFS, 2024).

Furthermore, the government provides training and extension services to improve technical expertise among small-scale farmers, making it more accessible for them to adopt sustainable practices. Within the Young Agropreneur Program, farmers are provided with resources to enhance their agricultural productivity. The government offers technical advice and training to facilitate their efforts (MAFS, 2024). Government agencies like the Malaysian Agricultural Research and Development Institute (MARDI) play a crucial role in offering technical guidance and training to farmers and entrepreneurs, including low-carbon farming technologies. MARDI is also actively engaged in assisting farmers in adopting agricultural technologies, particularly those developed by the institute. The process of technology transfer poses a complex and demanding challenge for farmers, highlighting the critical need for expert guidance and training to support adoption (Karim *et al*., 2021).

Meanwhile, the Malaysian Department of Agriculture has established the Malaysian Good Agricultural Practice (MyGAP) certificate to acknowledge farms that adhere to environmentally sustainable farming practices, prioritize worker well-being and safety, and produce high-quality, safe agricultural products (DOA, 2024). This certification is gaining credibility, particularly within the organic farming sector. Implementing MyGAP certification has been shown to increase crop yields and farmer income (Mohd Nawi *et al*., 2023), with rice cultivation under MyGAP has been found to generate higher revenue compared to conventional methods (Mohd Ali *et al*., 2021). The MyGAP certification underscores the importance of implementing eco-friendly farming methods, which align with the core principles of low-carbon agriculture aimed at reducing greenhouse gas emissions and optimizing resource utilization. Consequently, obtaining MyGAP certification can serve as a framework for farmers to integrate low-carbon practices into their agricultural operations, thereby fostering environmental sustainability and aiding in the mitigation of climate change. Although MyGAP certification offers significant advantages to farmers, its adoption is limited by demanding compliance requirements, certification costs, and administrative challenges. These barriers may discourage small-scale farmers from obtaining certification. Moreover, in addition to financial support for certification, sustained education and technical assistance are essential to ensure farmers can maintain low-carbon agricultural practices in the long term.

In addition, the Ministry of Natural Resources, Environment, and Climate Change (NRECC) also plays its part by continuing to strengthen low-carbon urban initiatives through fostering strategic collaboration among the Federal Government, State Governments, and Local Authorities (PBT). This collaborative effort aims to ensure that the transition toward low-carbon urban areas significantly contributes to mitigating the impact of climate change in Malaysia (NRECC, 2022). A low-carbon urban area is characterized by its adoption of strategies aimed at fulfilling environmental, social, and economic needs while reducing greenhouse gas emissions below the global average (Ministry of Environment and Water, 2021; Seberang Perai City Council, 2020). The policy framework for low-carbon urban development has garnered broad support and endorsement from various stakeholders. PLANMalaysia has taken proactive steps to develop guidelines for low-carbon urban planning and climate change resilience. These guidelines propose four strategic recommendations in the agricultural sector, covering both mitigation and adaptation approaches. These include the establishment of circular agricultural systems to minimize waste, the enhancement of sustainable water resource management, the promotion of sustainable smart agriculture through biofuel-to-energy initiatives, and the identification of suitable sites for community garden implementation (PLANMalaysia, 2023). These guidelines serve as a primary reference for stakeholders involved in low-carbon urban development. They incorporate a comprehensive collection of policy references developed by the government, such as Guidelines for Planning Vertical Mixed-Use Development in Commercial Zones, Urban Growth Boundary Planning Guidelines, Green Neighborhood Planning Guidelines, Urban Regeneration Implementation Guidelines in Kuala Lumpur, and others (PLANMalaysia, 2023).

Malaysia's policy and regulatory frameworks exemplify a holistic approach to harmonizing environmental sustainability with food security and economic viability. Through the implementation of these initiatives and guidelines, Malaysia is poised to make notable progress in constructing resilient, eco-conscious urban environments that play a constructive role in combating climate change.

CONCLUSION

In conclusion, it has become increasingly evident that there is a need to address the impact of climate change on agriculture. There is a global focus on reducing greenhouse gas emissions and promoting sustainable practices. Low-carbon farming offers a viable solution by implementing practices that reduce emissions while improving agricultural resilience and sustainability. Key strategies such as perennial crops, plant factories, and promoting healthy diets can significantly help mitigate the effects of climate change on agriculture. However, adopting low-carbon farming practices comes with challenges. Limited technical knowledge, financial constraints, and demographic factors hinder widespread implementation. Policies like those seen in Malaysia provide promising support for sustainable agricultural practices. By utilizing policy support, improving technical assistance, and fostering collaboration among stakeholders, countries can overcome barriers to low-carbon farming and facilitate the transition toward a more resilient and sustainable agricultural future.

Moreover, integrating low-carbon urban initiatives with agricultural policies can create synergies that promote overall sustainability and contribute to mitigating climate change at both local and global levels. In essence, integrating low-carbon farming practices into agricultural policies is a crucial step toward achieving climate resilience, food security, and environmental sustainability. With coordinated efforts and strategic investments, nations can harness the potential of low-carbon agriculture to build a more sustainable future for the next generations.

FUTURE DIRECTIONS AND RECOMMENDATIONS

The suggested future research entails an in-depth investigation of the existing technological infrastructure in Malaysia conducive to low-carbon agricultural practices. Future research should aim to evaluate the viability, scalability, and efficacy of such technologies in fostering sustainability and mitigating climate change within the agricultural domain. It should seek to pinpoint any deficiencies or potential enhancements within the existing technological frameworks and explore novel methodologies to facilitate the uptake of low-carbon farming techniques among Malaysian agricultural stakeholders.

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AUTHORS' CONTRIBUTIONS

Kartini conducted the literature search, analysis, and interpretation of the narrative review and drafted the manuscript. Nik Rozana and Nurul Huda reviewed and revised the manuscript for accuracy, ensuring it was factually correct, and provided critical feedback.

CONFLICT OF INTEREST

The authors declare no conflict of interest.