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Balancing Agricultural Energy Inputs and Outputs: Optimization Strategies and Sustainable Development

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Abstract This study involves assessing various agricultural practices and their energy efficiencies, environmental impacts, and potential for optimization. The study reveals several key findings across different agricultural systems. For instance, the use of multi-objective optimization algorithms in walnut production can significantly reduce energy consumption and environmental emissions, with gasoline being the most energy-saving input. Similarly, the introduction of cover crops as living mulch in Mediterranean organic cropping systems enhances energy outputs without increasing energy consumption, thereby improving energy efficiency. In cotton production, the major energy consumers are chemical fertilizers, diesel fuel, and irrigation water, with significant greenhouse gas emissions associated with these inputs. The study also highlights that sustainable soil and crop management strategies can optimize crop yield while minimizing environmental impacts. Furthermore, countries with higher organic production and input-intensive strategies show better progress towards sustainable development goals. In wheat production, optimizing energy inputs can lead to significant energy savings and reduced greenhouse gas emissions. Long-term field experiments indicate that fertilization and crop rotation can substantially improve energy efficiency in crop production. Finally, different fertilization methods in organic and sustainable farming show varying impacts on energy use efficiency, greenhouse gas emissions, and cost-effectiveness. The findings suggest that optimizing agricultural energy inputs and outputs through various strategies can significantly enhance energy efficiency, reduce environmental impacts, and promote sustainable development. Implementing these optimization strategies can help achieve a balance between agricultural productivity and environmental sustainability.

Keywords Agricultural energy inputs; Energy efficiency; Environmental emissions; Optimization strategies; Sustainable development; Multi-objective optimization; Cover crops; Organic farming; Greenhouse gas emissions

1 Introduction

Agricultural systems are inherently energy-intensive, relying on various inputs such as fertilizers, pesticides, water, and machinery to maintain productivity. The energy inputs in agriculture are crucial for enhancing crop yields and ensuring food security for a growing global population. However, the energy outputs, which include the harvested crops and their by-products, must be optimized to ensure that the energy invested in agricultural practices is efficiently converted into usable products. Studies have shown that the energy use efficiency in agricultural systems can vary significantly, with some systems demonstrating inefficiencies that need to be addressed for sustainable development (Schramski et al., 2013; Shah and Wu, 2019; Khanali et al., 2021).

Balancing energy inputs and outputs in agriculture is vital for several reasons. Firstly, it ensures the sustainability of agricultural practices by minimizing the environmental impact, such as greenhouse gas emissions and resource depletion (Ilahi et al., 2019; Montemurro et al., 2020). Secondly, optimizing energy use can lead to economic benefits for farmers by reducing input costs and improving energy efficiency (Bojacá et al., 2012; Schramski et al., 2013). Additionally, balanced energy use in agriculture can enhance food security by ensuring that energy resources are used effectively to produce sufficient food for the population (Davis et al., 2012; Sarkar et al., 2020). The importance of this balance is underscored by the need to meet the increasing food demands of a growing population while preserving the environment for future generations (Shah and Wu, 2019; Maitra et al., 2021).

By examining various case studies and research findings, this study will highlight effective strategies for improving energy efficiency and reducing environmental impacts in agricultural systems. The scope of this study includes an analysis of different cropping systems, energy balance methodologies, and the role of innovative technologies in achieving sustainable agricultural practices. Through this exploration, the study seeks to contribute to the ongoing efforts to develop sustainable agricultural systems that can meet the food demands of the present and future generations.

2 Overview of Agricultural Energy Inputs

2.1 Types of energy inputs in agriculture

Agricultural energy inputs can be broadly categorized into direct and indirect energy inputs. Understanding these categories is crucial for optimizing energy use and promoting sustainable agricultural practices.

2.1.1 Direct energy inputs (fuel, electricity)

Direct energy inputs in agriculture primarily include fuel and electricity. Fuel is used for operating machinery such as tractors, harvesters, and irrigation pumps, while electricity powers various farm operations, including lighting, heating, and cooling systems. The efficiency of these direct energy inputs can significantly impact the overall energy balance of agricultural systems. For instance, the use of diesel fuel in crop production has been shown to vary significantly depending on the type of crop and cultivation method, with higher fuel consumption observed in more intensive farming practices (Romaneckas et al., 2023).

2.1.2 Indirect energy inputs (fertilizers, pesticides, machinery)

Indirect energy inputs encompass the energy required to produce and transport agricultural inputs such as fertilizers, pesticides, and machinery. Fertilizers and pesticides are particularly energy-intensive to manufacture, contributing significantly to the total energy input in agricultural systems. For example, the energy input from fertilizers alone can account for up to 55% of the total energy required in certain cropping systems (Montemurro et al., 2020). Additionally, the production and maintenance of agricultural machinery also represent substantial indirect energy inputs (Moitzi et al., 2021).

2.2 Trends in energy input usage

Recent trends in agricultural energy input usage indicate a growing emphasis on optimizing energy efficiency and reducing reliance on non-renewable energy sources. Studies have shown that integrating cover crops and no-till practices can enhance energy efficiency without compromising crop yields (Montemurro et al., 2020). Furthermore, long-term experiments have demonstrated that crop rotation and the use of organic fertilizers, such as farmyard manure, can significantly improve energy use efficiency compared to conventional mineral fertilizers (Moitzi et al., 2021). These trends highlight the potential for sustainable practices to reduce energy inputs while maintaining or even increasing agricultural productivity.

2.3 Environmental and economic impacts of energy inputs

The environmental and economic impacts of agricultural energy inputs are profound. The overuse of fertilizers and pesticides not only leads to soil degradation and water pollution but also contributes to greenhouse gas emissions, exacerbating climate change (Shah and Wu, 2019; Bashir et al., 2022). Economically, the high cost of energy inputs can strain farmers' budgets, particularly in regions with limited access to affordable energy sources. However, adopting energy-efficient practices, such as efficient nutrient management and integrated crop management, can mitigate these negative impacts. For instance, reducing the use of chemical inputs and improving crop input use efficiency can lower greenhouse gas emissions and enhance environmental sustainability (Shah and Wu, 2019; Bashir et al., 2022).

In conclusion, balancing agricultural energy inputs and outputs through optimization strategies is essential for sustainable development. By understanding the types of energy inputs, monitoring trends in their usage, and addressing their environmental and economic impacts, we can develop more sustainable agricultural systems that meet the growing food demands while protecting the environment.

3 Agricultural Energy Outputs

3.1 Types of energy outputs (crops, livestock, by-products)

Agricultural energy outputs encompass a variety of products, including crops, livestock, and by-products. Crops such as wheat, rice, and vegetables are primary energy outputs, providing essential food and bioenergy resources. Livestock, including cattle, poultry, and other farm animals, contribute significantly to energy outputs through meat, milk, and other animal products. By-products, such as crop residues and manure, also play a crucial role in the agricultural energy balance, offering potential for bioenergy production and soil fertility enhancement (Shah and Wu, 2019; Ilahi et al., 2019; Kosemani and Bamgboye, 2020; Moitzi et al., 2021).

3.2 Measuring agricultural productivity and efficiency

Measuring agricultural productivity and efficiency involves evaluating the energy inputs and outputs within farming systems. Key metrics include energy use efficiency, net energy gain, and energy productivity. For instance, in wheat production, energy use efficiency and net energy gain are critical indicators, with studies showing values of 1.4 MJ kg^{-1} and 13 836.07 MJ ha^{-1}, respectively (Ilahi et al., 2019). Similarly, energy input-output analysis in rice production reveals significant differences in energy efficiency across farm sizes, with larger farms demonstrating better energy management and higher energy ratios (Kosemani and Bamgboye, 2020). These measurements help identify areas for optimization and sustainable practices in agriculture (Ilahi et al., 2019; Kosemani and Bamgboye, 2020; Khanali et al., 2021).

3.3 Energy output trends and challenges

Recent trends in agricultural energy outputs highlight the increasing importance of optimizing energy use to enhance productivity and sustainability. For example, the use of cover crops and no-till practices in Mediterranean organic cropping systems has been shown to improve energy outputs without compromising energy consumption (Montemurro et al., 2020). However, challenges such as the high energy demand for fertilizers and fuel, as seen in walnut and wheat production, underscore the need for more efficient energy management strategies (Ilahi et al., 2019; Khanali et al., 2021) (Figure 1). Additionally, urban agriculture, while highly productive, faces challenges in balancing input costs and sustainability, necessitating careful management of resources to achieve high yields (McDougall et al., 2018). Addressing these challenges through innovative practices and technologies is essential for sustainable agricultural development (McDougall et al., 2018; Shah and Wu, 2019; Montemurro et al., 2020).

Ilahi et al. (2019) illustrates the proportion of energy savings from different inputs in sustainable wheat production. Fertilizer constitutes the largest share at 57%, highlighting its significant impact on energy consumption. Diesel fuel (10%), machinery (9%), and electricity (7%) also contribute notable portions to energy savings. Other inputs like seed (6%), human labor (1%), and weedicides (5%) contribute smaller percentages, indicating that these resources are being efficiently utilized. The funnel diagram emphasizes the integration of economic, environmental, and social indicators to achieve sustainable wheat production. The study underscores the importance of optimizing fertilizer and diesel fuel usage to enhance sustainability. The findings align with previous studies on paddy and soybean production, confirming the critical role of fertilizers and fuel in energy savings. This comprehensive approach ensures a balanced and sustainable agricultural practice that benefits the economy, environment, and society.

4 Optimization Strategies for Balancing Energy Inputs and Outputs

4.1 Precision agriculture technologies

4.1.1 GPS and GIS technology

Precision agriculture technologies, such as GPS and GIS, play a crucial role in optimizing resource use and improving crop management. These technologies provide detailed information on crop growth, soil variability, and nutrient levels, enabling site-specific management practices that enhance productivity and sustainability. For instance, the integration of GPS and GIS tools allows for precise mapping and monitoring of crops, soil, and weather conditions, which can significantly improve resource use efficiency and reduce environmental impact (Onyango et al., 2021; Sharma and Srushtideep, 2022; Prabha and Pathak, 2023).

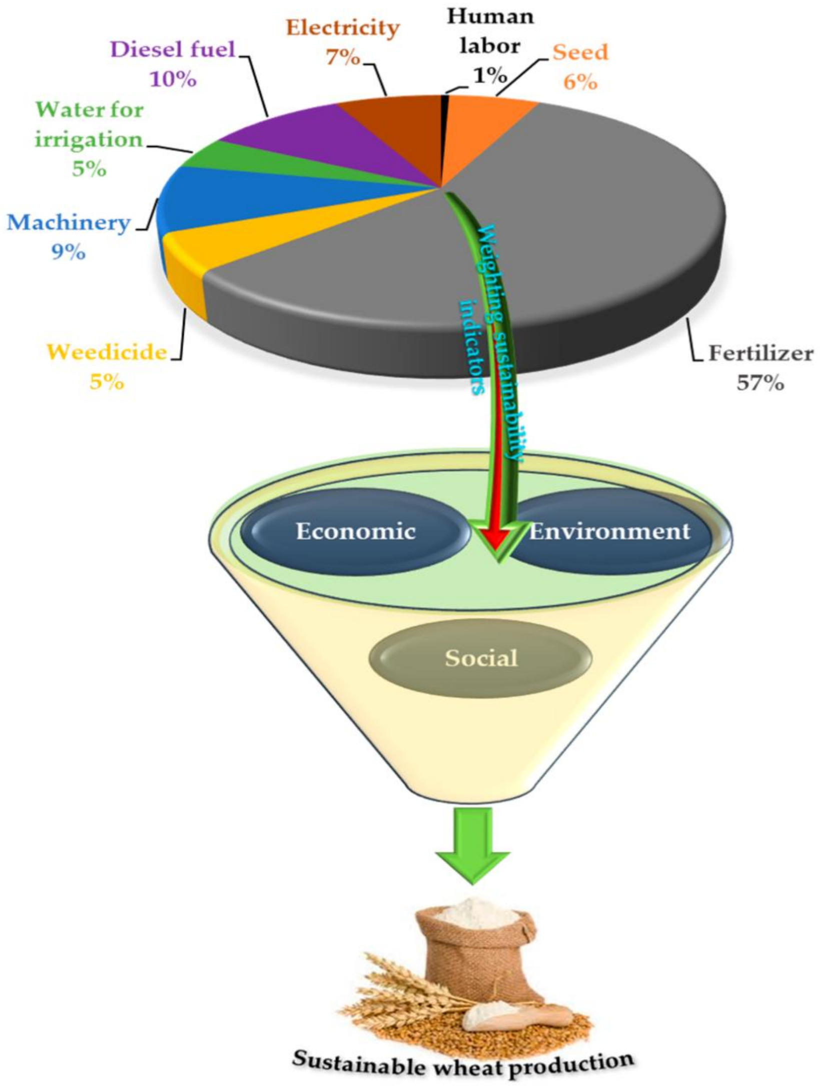

Figure 1 Share of energy saving from various sources for sustainable wheat production (Adopted from Ilahi et al., 2019)

4.1.2 Remote sensing and drones

Remote sensing and drones are essential components of precision agriculture, offering real-time data collection and analysis. These technologies facilitate crop health monitoring, early disease detection, and efficient water and nutrient management. The use of drones for crop mapping and monitoring can lead to better decision-making and optimized input application, ultimately enhancing crop yields and reducing resource wastage (Ahmad and Dar, 2020; Onyango et al., 2021; Abbas et al., 2022).

4.2 Sustainable farming practices

4.2.1 Crop rotation and diversification

Crop rotation and diversification are fundamental sustainable farming practices that help maintain soil health and reduce pest and disease pressures. By alternating different crops, farmers can break pest cycles, improve soil fertility, and enhance biodiversity. These practices contribute to a more resilient agricultural system and can lead to higher energy efficiency and productivity (Shah and Wu, 2019; Montemurro et al., 2020).

4.2.2 Organic farming

Organic farming emphasizes the use of natural inputs and ecological processes to maintain soil health and reduce environmental impact. This approach avoids synthetic fertilizers and pesticides, promoting biodiversity and soil fertility. Studies have shown that organic farming can enhance energy efficiency and sustainability by reducing the reliance on non-renewable energy sources and minimizing greenhouse gas emissions (Smith et al., 2022).

4.2.3 Agroforestry

Agroforestry integrates trees and shrubs into agricultural landscapes, providing multiple benefits such as improved soil structure, enhanced biodiversity, and increased carbon sequestration. This practice can also contribute to energy efficiency by reducing the need for external inputs and enhancing the resilience of farming systems to climate change (Shah and Wu, 2019).

4.3 Renewable energy integration

4.3.1 Solar and Wind Energy

Integrating renewable energy sources like solar and wind into agricultural operations can significantly reduce the reliance on fossil fuels and lower greenhouse gas emissions. Solar panels and wind turbines can be used to power irrigation systems, machinery, and other farm operations, promoting a more sustainable and energy-efficient agricultural system (Abbas et al., 2022; Maraveas, 2022).

4.3.2 Bioenergy from agricultural residues

Bioenergy production from agricultural residues, such as crop waste and animal manure, offers a sustainable way to manage waste and generate renewable energy. This approach can help balance energy inputs and outputs by converting organic waste into biogas or biofuels, which can be used to power farm operations or sold as an additional income source (Abbas et al., 2022) (Figure 2).

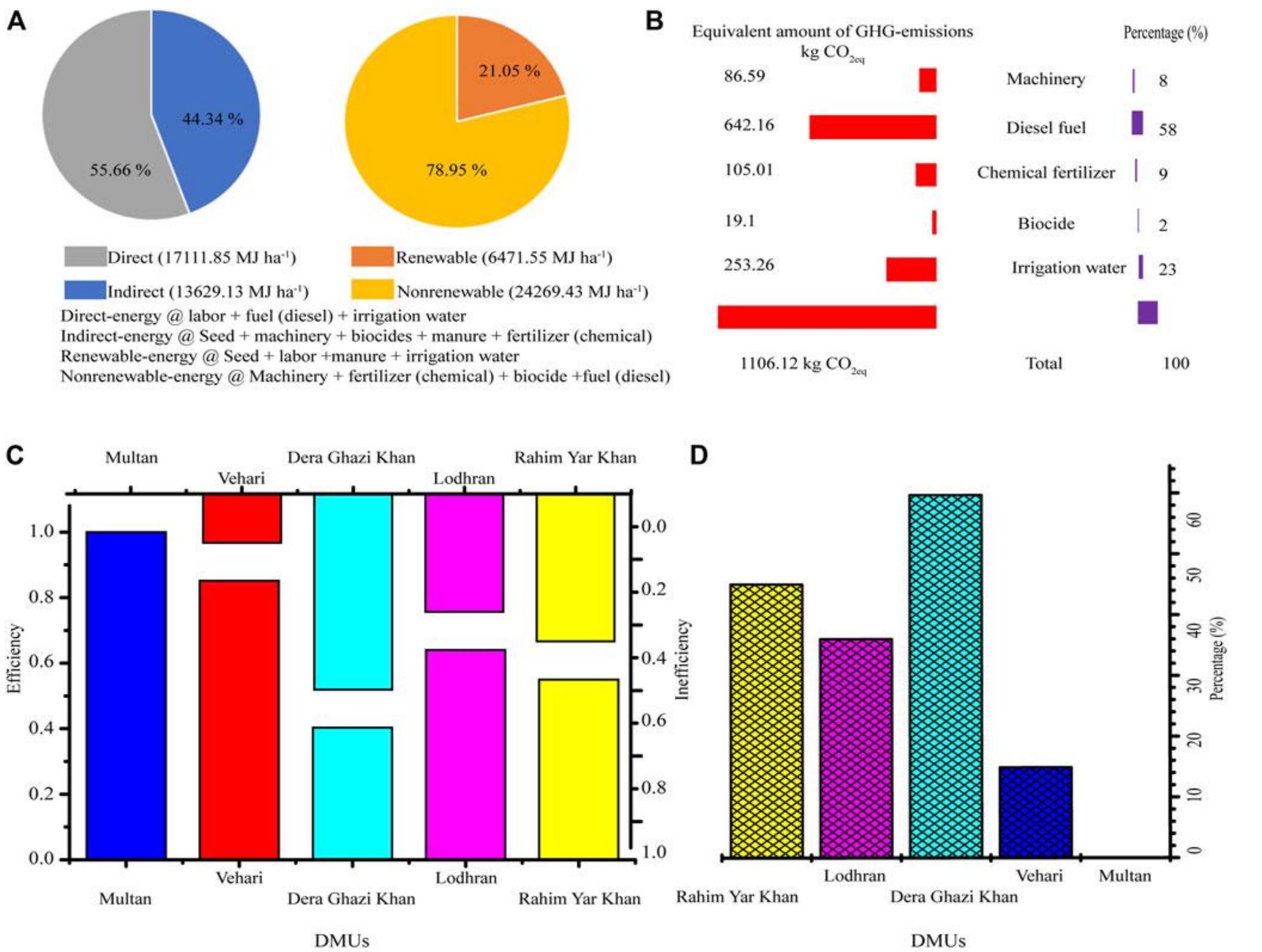

Figure 2 Energy Shares, GHG Emissions, and Efficiency Scores in Cotton Production across Selected Districts (Adapted from Abbas et al., 2022)

Note: (A): Breakdown of direct and indirect, renewable, and nonrenewable energy consumption in cotton production; (B): Contributions of various inputs to total GHG emissions (kg CO2eq ha^{-1}) in cotton production; (C): Efficiency scores for cotton production in different districts, using an input-oriented CCR model; (D): Potential resource savings in each district based on technical efficiency (Adapted from Abbas et al., 2022)

Abbas et al. (2022) illustrates the energy consumption, GHG emissions, and technical efficiency of cotton production in selected districts of Punjab, Pakistan. Panel (A) shows that nonrenewable energy sources, mainly from fossil fuels, dominate with 78.95% of the total energy, whereas renewable sources contribute only 21.05%. Panel (B) highlights that diesel fuel and irrigation water are the primary sources of GHG emissions, contributing 58% and 23% respectively, emphasizing the need for more efficient fuel use and water management in cotton farming. Panel (C) presents the technical efficiency scores, with Multan (DMU5) being the most efficient district. Panel (D) illustrates the potential resource savings if other districts improve their efficiency to the level of Multan, suggesting significant room for enhancing productivity and sustainability in cotton production.

4.4 Energy-efficient machinery and equipment

The adoption of energy-efficient machinery and equipment is crucial for reducing energy consumption and improving overall farm efficiency. Modern agricultural machinery equipped with advanced technologies, such as precision planting and variable rate application, can optimize input use and minimize energy wastage. Additionally, regular maintenance and proper calibration of equipment can further enhance energy efficiency and contribute to sustainable agricultural practices (Abbas et al., 2022; Maraveas, 2022).

5 Case Studies and Best Practices

5.1 Successful implementation of optimization strategies

Several case studies highlight the successful implementation of optimization strategies in agricultural systems. For instance, a study conducted in northeast China demonstrated the potential of optimizing bioenergy production by considering the energy-food-water-land nexus and livestock manure under uncertainty. This approach provided decision-makers with optimal policy options and helped identify sustainability levels in agricultural systems, ultimately promoting agricultural economy while mitigating environmental side-effects (Li et al., 2020). Another example is the use of data envelopment analysis (DEA) to optimize energy consumption in rice-wheat-green gram cropping systems under conservation tillage practices. This study found that zero tillage with 0% residue retention minimized total energy input, while reduced tillage with 0% paddy straw residue and 100% N.P.K. maximized yield energy, showcasing the effectiveness of conservation tillage in energy optimization (Bhunia et al., 2021).

5.2 Comparative analysis of different regions and farming systems

Comparative analysis of different regions and farming systems reveals significant variations in energy optimization practices and outcomes. In China, a multi-objective optimization model was used to balance employment, energy consumption, water use, carbon emissions, and pollutant emissions across various provinces. The study concluded that an energy-consumption-dominated industrial restructuring pathway was the most effective in achieving sustainable development goals, highlighting the importance of regional equity and policy prioritization (Wang et al., 2020) (Figure 3). In Sri Lanka, an assessment of energy balance in diversified agricultural systems showed a negative energy balance in crop production, indicating an efficient production system, while the livestock sector exhibited higher energy loss. This study underscores the need for region-specific strategies to optimize energy use in agriculture (Dhanapala et al., 2023).

Wang et al. (2020) demonstrates how total outputs by province change under three different scenarios compared to a baseline. In the employment-dominated scenario (a), most regions experience increased outputs, fostering regional development. The energy-consumption-dominated scenario (b) indicates a focus on balancing production levels, promoting central provinces while reducing outputs in some northern and eastern regions. The carbon-emissions-dominated scenario (c) highlights the sacrifices required in various provinces to meet emission targets, suggesting that only a few provinces benefit. This analysis suggests that an energy consumption policy could promote regional equity, balancing industrial growth across different provinces.

5.3 Lessons learned and replicable models

The lessons learned from these case studies provide valuable insights for replicable models in other regions. The multi-objective optimization model used in China can serve as a comprehensive approach for policymakers to support sustainable development policies by balancing various resource uses and emissions (Wang et al., 2020).

The optimization-assessment approach for bioenergy production in northeast China can be applied to similar agriculture-centered regions to manage bioenergy production sustainably, considering the complexities due to uncertainties (Li et al., 2020). Additionally, the energy budgeting and optimization techniques used in the rice-wheat-green gram cropping system can be adapted to other cropping systems to enhance energy efficiency and conservation (Bhunia et al., 2021). These models demonstrate that tailored optimization strategies, considering regional and system-specific factors, are crucial for achieving sustainable agricultural development.

By examining these successful implementations, comparative analyses, and lessons learned, we can develop and replicate effective optimization strategies to balance agricultural energy inputs and outputs, contributing to sustainable development in diverse agricultural contexts.

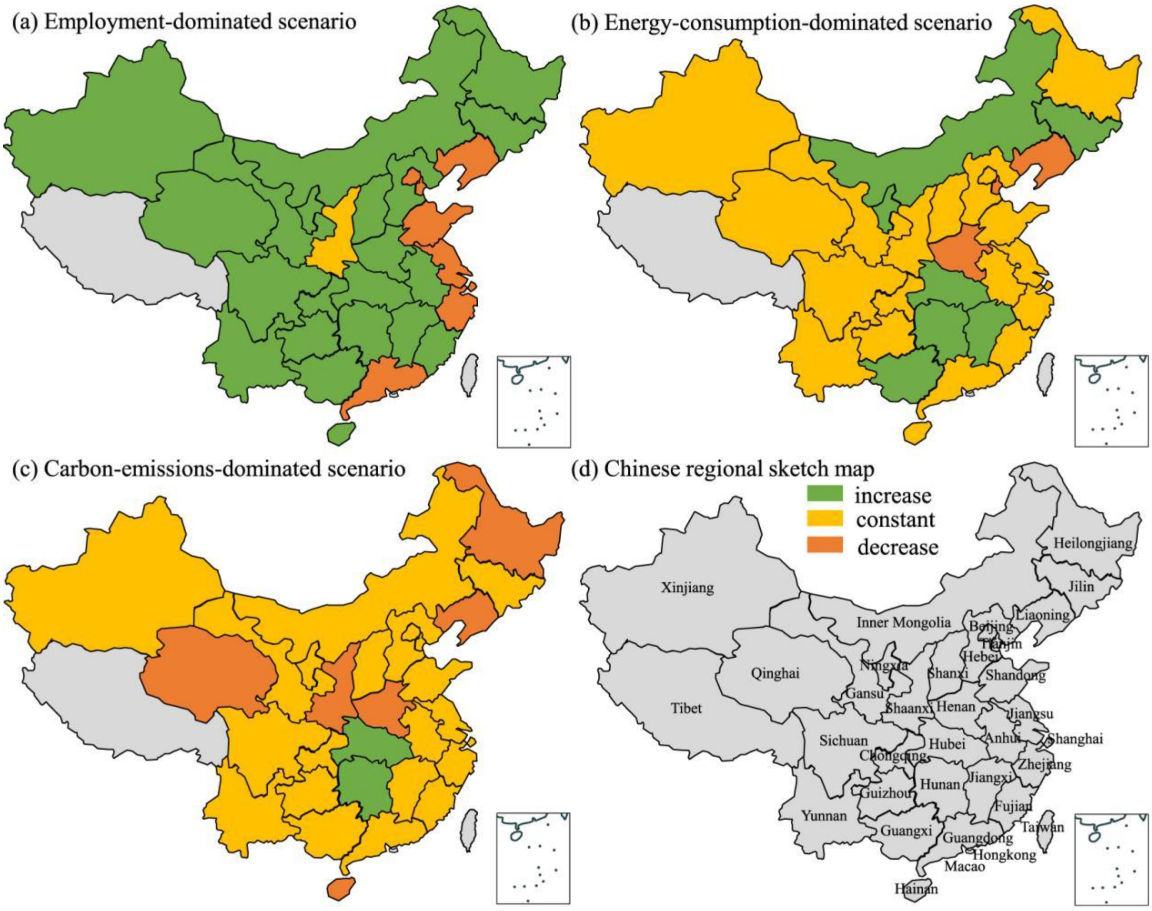

Figure 3 Regional Changes in Total Outputs by Province under Different Scenarios (Adapted frrom Wang et al., 2020)
Note: (a) Employment-dominated scenario: Most regions show an increase in total output, except for constant output in Shaanxi and decreased outputs in Beijing, Tianjin, and coastal provinces; (b) Energy-consumption-dominated scenario: Provinces in central regions (Inner Mongolia, Hubei, Hunan, Guangxi, Jiangxi) increase production levels, while Liaoning, Tianjin, and Henan decrease production levels; (c) Carbon-emissions-dominated scenario: Only Hubei and Hunan benefit, with decreased outputs in Heilongjiang, Liaoning, Hunan, Shaanxi, Qinghai, and Hainan; (d) Chinese regional map: Provinces are marked for reference (Adapted frrom Wang et al., 2020)

6 Policy and Regulatory Framework

6.1 Current policies impacting agricultural energy balance

Current policies significantly influence the energy balance in agriculture, with a focus on reducing fossil fuel dependency and promoting sustainable practices. For instance, the European Union has enforced regulations to reduce carbon dioxide emissions and promote renewable energy sources, which has led to a transformation in energy balances across European countries and Turkey (Jonek-Kowalska, 2019). Similarly, China's 13th Five Year Plan (2016-2020) includes policies aimed at balancing energy consumption, water use, and emissions through industrial restructuring (Wang et al., 2020). These policies are crucial in guiding agricultural practices towards sustainability by encouraging the use of renewable energy and optimizing resource use.

6.2 Recommendations for policy improvements

To further enhance the energy balance in agriculture, several policy improvements are recommended:

(1)Incentivize Renewable Energy Use: Policies should provide financial incentives for the adoption of renewable energy sources in agriculture. This could include subsidies for solar panels, wind turbines, and bioenergy production (Lu et al., 2020).

(2)Promote Energy Efficiency: Implementing standards and certifications for energy-efficient farming practices can help reduce overall energy consumption. For example, energy-efficiency standards have been successful in building energy savings and could be adapted for agricultural use (Lu et al., 2020).

(3)Support Research and Development: Increased funding for research into sustainable agricultural practices and technologies can lead to innovations that reduce energy inputs and enhance outputs. This includes the development of low-input sustainable agriculture (LISA) technologies that minimize environmental trade-offs (Sarkar et al., 2020).

(4)Encourage Integrated Management Practices: Policies should promote integrated nutrient and soil management practices that optimize energy use and improve crop yields sustainably (Shah and Wu, 2019).

6.3 Role of government and international organizations

Governments and international organizations play a pivotal role in shaping and implementing policies that balance agricultural energy inputs and outputs. National governments can enact regulations and provide subsidies to encourage sustainable practices. For example, the French government has explored the potential of achieving energy neutrality in agriculture by balancing energy consumption with energy recovery from internal sources (Harchaoui and Chatzimpiros, 2018).

International organizations, such as the United Nations and the European Union, can facilitate the sharing of best practices and provide frameworks for international cooperation. The Paris Agreement on climate change is a prime example of an international effort to reduce greenhouse gas emissions, which includes commitments from the agricultural sector to adopt more sustainable practices (Platis et al., 2019). Additionally, organizations like the Food and Agriculture Organization (FAO) can support capacity-building initiatives and provide technical assistance to developing countries to implement sustainable agricultural practices (Sarkar et al., 2020).

By working together, governments and international organizations can create a robust policy and regulatory framework that promotes the sustainable development of agriculture, ensuring that energy inputs are optimized and outputs are maximized in an environmentally friendly manner.

7 Challenges and Future Directions

7.1 Barriers to optimizing energy inputs and outputs

Optimizing energy inputs and outputs in agriculture faces several significant barriers. One of the primary challenges is the lack of policies that promote innovative practices, which is a critical external barrier preventing the adoption of sustainable agricultural innovations (Campuzano et al., 2023). Additionally, unfavorable regulations and the high cost of agrochemicals further complicate efforts to optimize energy use, particularly in developing countries where subsistence farmers are most vulnerable to these economic pressures (Sarkar et al., 2020). Internal barriers such as epistemic closure and unskilled labor also hinder the adoption of new technologies and practices that could improve energy efficiency (Campuzano et al., 2023). Moreover, the structural energy deficiency in current agricultural systems, where the energy requirements almost equal the final produce, poses a substantial challenge to achieving energy neutrality (Harchaoui and Chatzimpiros, 2018).

7.2 Emerging technologies and innovations

Emerging technologies and innovations offer promising solutions to the challenges of optimizing energy inputs and outputs in agriculture. Low-input sustainable agriculture (LISA) technologies, which aim to reduce the negative environmental impacts of agricultural production, are gaining traction. These technologies include crop simulation models that help predict crop growth and yield under various climatic scenarios, thereby aiding in the efficient use of resources (Sarkar et al., 2020). Additionally, soil and crop management strategies (SCMS) such as integrated nutrient management (INM), integrated soil fertility management (ISFM), and conservation agriculture (CA) are designed to optimize crop yield while maintaining environmental sustainability (Shah and Wu, 2019; Bashir et al., 2022). Urban agriculture, although currently inefficient in its use of material and labor resources, shows potential for high productivity and could be made more sustainable through the substitution of nonrenewable inputs with local renewable ones (McDougall et al., 2018).

7.3 Future research needs and opportunities

Future research should focus on developing and implementing policies that support the adoption of sustainable agricultural practices and technologies. This includes formulating guidelines, incentives, and regulations that address the external barriers identified (Campuzano et al., 2023). Research is also needed to improve the efficiency of crop simulation models to better predict the response of multiple cropping systems under changing climatic conditions (Sarkar et al., 2020). Additionally, there is a need for studies that explore the potential of urban agriculture to contribute to food security while minimizing environmental impacts (McDougall et al., 2018). Investigating the long-term impacts of various soil and crop management strategies on soil health and crop productivity will also be crucial for developing sustainable agricultural systems (Shah and Wu, 2019; Bashir et al., 2022). Finally, interdisciplinary research that combines technological innovations with behavioral changes among farmers could provide comprehensive solutions to the challenges of optimizing energy inputs and outputs in agriculture.

8 Concluding Remarks

The research on balancing agricultural energy inputs and outputs has highlighted several critical aspects. Key findings indicate that chemical fertilizers, diesel fuel, and irrigation water are the primary energy consumers in various agricultural systems, significantly contributing to greenhouse gas emissions. Studies have shown that optimizing these inputs can lead to substantial energy savings and reduced environmental impact. Additionally, innovative soil and crop management strategies, such as integrated nutrient management and conservation agriculture, have been identified as effective means to enhance energy efficiency and sustainability in agricultural practices.

The implications of these findings for sustainable agricultural development are profound. By adopting optimized energy use practices and sustainable management strategies, farmers can achieve higher crop yields while minimizing environmental degradation. For instance, the use of cover crops and no-till farming has been shown to improve energy efficiency without compromising crop yields. Moreover, the implementation of low-input sustainable agriculture (LISA) can help mitigate the adverse effects of climate change and ensure food security in developing regions. These strategies not only enhance the resilience of agricultural systems but also contribute to the broader goals of sustainable development by reducing greenhouse gas emissions and conserving natural resources.

In conclusion, the optimization of energy inputs and outputs in agriculture is essential for achieving sustainable development. It is recommended that policymakers and stakeholders promote the adoption of energy-efficient practices and sustainable management strategies. This includes encouraging the use of renewable energy sources, improving the efficiency of irrigation systems, and reducing the reliance on chemical fertilizers and pesticides. Additionally, further research should focus on developing and disseminating innovative technologies and practices that enhance energy efficiency and sustainability in agriculture. By doing so, we can ensure a more sustainable and resilient agricultural sector that meets the growing food demands while protecting the environment for future generations.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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