Challenges in Sustainability
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Agriculture's Role in Environmental Sustainability: A Comprehensive Review of Challenges and Solutions

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Received: 08-10-2024 **Revised:** 10-12-2024 **Accepted:** 10-20-2024

Citation: Mahmood, H., Hassan, M. S., Meraj, G., & Furqan, M. (2024). Agriculture's role in environmental sustainability: A comprehensive review of challenges and solutions. *Chall. Sustain.*, *12*(3), 178-189. https://doi.org/10.56578/cis120302.

Abstract: The growing global population has placed increasing pressure on the agriculture sector to meet rising food demand, posing significant environmental and ecological challenges. This review systematically examines 70 studies selected from the Scopus database, with a focus on the environmental impacts of agriculture and potential mitigation strategies. Of the 70 articles, 38 studies explore the macroeconomic environmental effects of agriculture. While 10 studies report positive environmental contributions from the sector, 23 highlight adverse ecological consequences. Additionally, various studies indicate U-shaped, inverted U-shaped, or N-shaped relationships between agricultural activities and pollution levels. Livestock production and the extensive use of synthetic fertilisers are identified as major contributors to greenhouse gas (GHG) emissions, while the widespread use of pesticides and herbicides has been shown to cause soil and water contamination. Further environmental degradation is linked to deforestation driven by agricultural expansion, which reduces carbon sinks and biodiversity. The agriculture sector's dependence on fossil fuels also exacerbates its GHG emissions, while its significant freshwater consumption heightens concerns about water scarcity. Moreover, soil degradation, often resulting from monocropping and conventional farming practices, presents an ongoing challenge. However, sustainable agricultural practices, such as agroforestry, crop rotation, conservation tillage, and organic farming, offer promising solutions to mitigate these environmental impacts. These practices not only enhance soil health by reducing chemical inputs but also promote biodiversity within farming systems. Precision agriculture, optimisation of water, fertiliser, and pesticide usage, the adoption of native plant species, and the integration of renewable energy sources have been identified as key strategies for improving the sustainability of agricultural operations. Additionally, genetic advancements in crop development may play a critical role in addressing the sector's environmental footprint. By adopting these sustainable methods, the agriculture sector has the potential to increase productivity while significantly reducing its environmental impact, contributing to the overall goal of ecological sustainability.

Keywords: Agriculture; Food demand; Environmental sustainability; Pollution; Sustainable farming practices; Greenhouse gas (GHG) emissions; Soil degradation; Water scarcity

1. Introduction

The global population is rising at a faster rate, which is expected to increase global food demand and put pressure on the agriculture sector to meet the increasing demand for food and other agricultural products. However, the increasing agriculture sector could have a contribution to environmental degradation. For instance, the agriculture sector emits GHG from livestock, fertilizers, and chemicals (Furtak et al., 2024). Moreover, the rising demand for agricultural products might result in deforestation, which would reduce carbon sinks and biodiversity (Masolele et al., 2024). In addition, fossil fuels for agriculture machinery and transportation could increase GHG emissions (Qin et al., 2024). Furthermore, waste from the agriculture supply chain might also increase water pollution and GHG emissions (Srivastav et al., 2024). In addition, the agriculture sector increases water withdrawals (Wisser et al., 2024). Monocropping and conventional farming methods might degrade soil, which decreases soil organic matter and fertility.

Along with the negative environmental side of the agriculture sector, this sector may also improve the environment by adopting sustainable agriculture practices. For instance, polycultures, organic farming, agroforestry, cover cropping, resistant crop varieties, and crop rotation might enhance soil fertility and soil structure. Besides, these practices could decrease the usage of chemical fertilizers and pesticides and could reduce pollution. Moreover, conservation tillage maintains soil organic matter and reduces its erosion, which might improve soil structure and water retention (Ma et al., 2024). Moreover, enhancing livestock feed quality and biogas production from crops and livestock residues can reduce GHG emissions (Wang et al., 2024). In addition, optimizing the usage of farms' inputs and adopting organic farming can reduce water pollution and conserve agriculture resources. Moreover, integrated pest and manure management can reduce the demand for chemical pesticides. Besides, integrating native plants in farms and reinstating degraded lands would improve soil health and agricultural productivity (Blanco-Canqui, 2024). Last but not least, replacing renewable energy with fossil fuels and increasing energy efficiency in the agriculture sector can reduce GHG emissions (Peng et al., 2024). Adopting the mentioned sustainable practices could help the agriculture sector to protect the environment and conserve agriculture resources for a sustainable agriculture future.

Considering both positive and negative environmental aspects of the agriculture sector, the recently reviewed literature has been conducted as global perspective studies and country-specific studies covering the dimensions of eco-innovation (Praveen et al., 2024), artificial intelligence for circular agriculture economy (Ali et al., 2024), biomass as a soil amendment (Rehman & Thengane, 2024), environmental effects of rice straw management (Singh et al., 2024), analysis of carbon capture and storage (Apriantoro et al., 2024), and digital farming (Ammar et al., 2024). However, a comprehensive study exploring the maximum positive and negative environmental dimensions of the agriculture sector is still missing in the review literature. The present study is going to fill this gap. To increase the novelty and scope of the research, the present study also reviewed the studies with macroeconomic scope to conclude about the aggregate effect of the agriculture sector on environmental sustainability in the economies. Thus, the present paper works on the research questions. For instance, how do traditional agricultural practices contribute to GHG emissions and soil, water, and biodiversity loss? In contrast, what are modern sustainable agricultural practices that can help to reduce the negative environmental impacts of conventional farming? Lastly, what is the macroeconomic impact of the agriculture sector on the aggregate environment in the economies, and how can policies support the transition toward sustainable agriculture?

2. Literature Survey Methodology

We use the systemic review approach to collect the studies on the topic of positive and negative environmental effects of the agriculture sector from the Scopus database. For this purpose, we searched the appropriate keywords within the title, abstract, and keywords by using the command in advance search as TITLE-ABS-KEY ("Agriculture" OR "Agriculture productivity" OR "Agriculture production" OR "Farming" OR "Livestock" OR "Harvesting") AND ("Air pollution" OR "Water pollution" OR "Emissions" OR "Soil health" OR "Water use" OR "Salinization" OR "Dust and particulate matter" OR "Manure" OR "Deforestation" OR "Waste management" OR "Agriculture Energy" OR "Ecosystem"). We get 1391 articles by putting the filters of subject area "Economics, Econometrics, and Finance", periodic range 2020-2024, document type "article" and "review", and language "English". Thus, we focus on the latest literature from 2020, including research papers, review studies, and meta-analyses investigating the positive and negative environmental impacts of the agriculture sector. Later, we read titles and keywords to select articles focusing on sustainable agricultural practices along with exploring the negative environmental effects of traditional agriculture practices. Particularly, we focus on the studies carrying broader themes of the agriculture sector, including air, soil, and water health related to the usage of energy, fertilizers, pesticides, and herbicides, environmental issues related to deforestation, and some modern sustainable agricultural practices to mitigate environmental and ecological problems. We exclude the literature having a narrow focus and lacking broader environmental implications. Moreover, we exclude the literature carrying the same conclusions. Finally, we select 70 articles for review and start reading the full text to approach the most significant research findings as per the objectives of the paper.

3. The Potential Negative Environmental Effects of the Agriculture Sector

The agriculture sector could lead to environmental problems in different ways. Figure 1 shows the expected negative environmental effects of the agriculture sector. For instance, livestock could produce methane during digestion (Furtak et al., 2024), which could contribute to GHG emissions. Further, livestock farming could also increase ammonia from the manure of livestock dung, which could form particulate matter (PM2.5) interacting with other pollutants (Huang et al., 2024). The use of nitrogen fertilizers and manure could also contribute to GHG emissions by releasing Nitrous Oxide (N_2O) (Li et al., 2024). These mentioned emissions cause respiratory and cardiovascular diseases, which damage human health. In addition, chemicals in pesticides and herbicides could contribute to environmental degradation and biodiversity loss (Lozano & Pizarro, 2024). For instance, these chemicals could harm non-targeted species like insects, birds, and mammals.

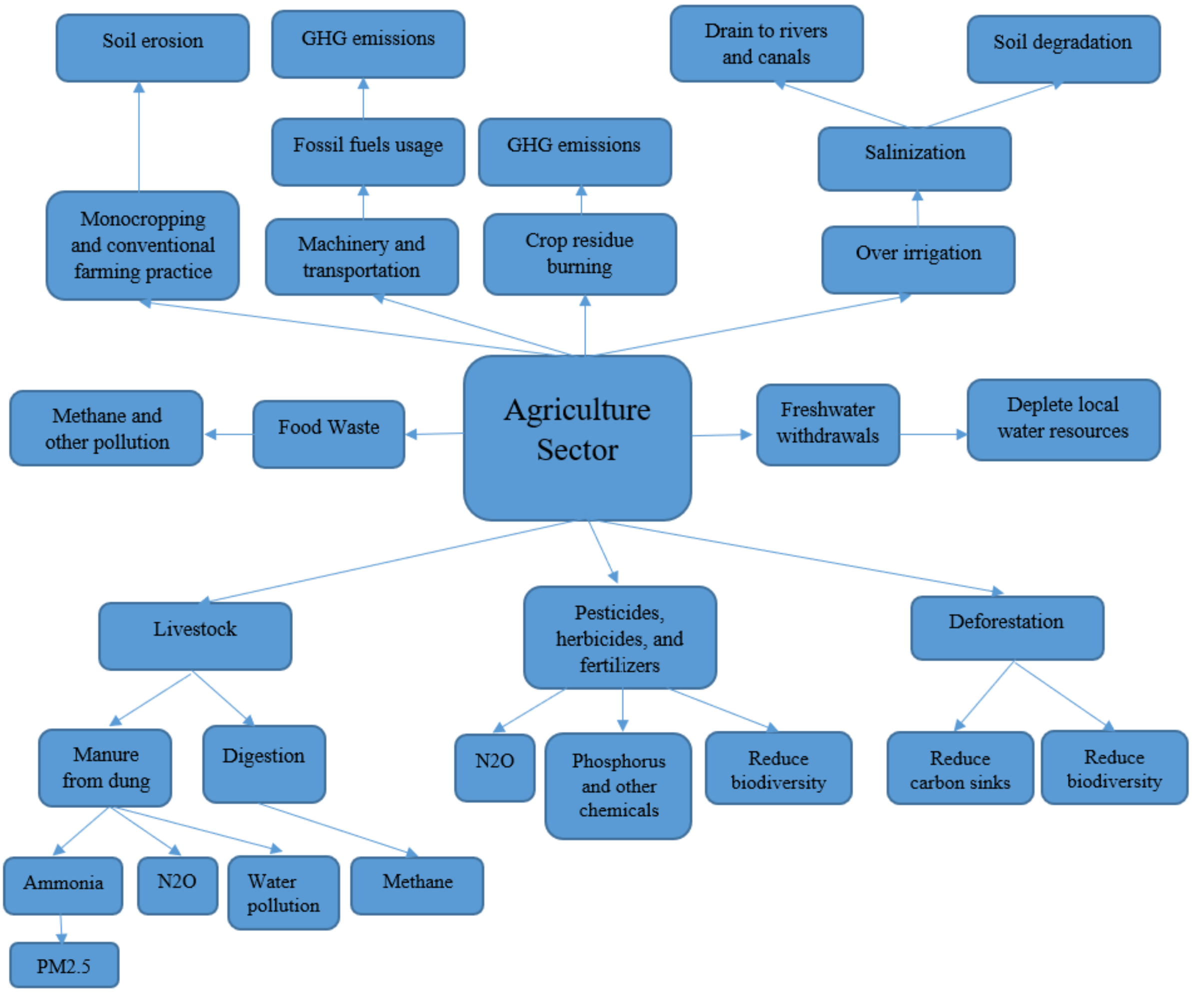

Figure 1. Negative environmental effects of the agriculture sector

The expansion of the agricultural land for cultivation would cause deforestation. The resultant deforestation carries environmental consequences as forests carry carbon sinks and are also maintaining biodiversity (Masolele et al., 2024). Thus, deforestation could increase carbon dioxide (CO_2) emissions. Moreover, the usage of grasslands and forests for farming would increase wildlife migration, which could decrease biodiversity. Besides, fossil fuels are used in agricultural machinery and transportation, which could increase GHG emissions (Qin et al., 2024). Furthermore, waste from the food supply chain could increase methane emissions (Srivastav et al., 2024). Besides, crop residue burning to produce electricity would also have environmental problems as well.

The agriculture sector could also be responsible for water pollution. For instance, the usage of pesticides, herbicides, and fertilizers releases nitrogen and phosphorus, which might pollute water during rain or irrigation (AbuQamar et al., 2024). Thus, these can harm aquatic ecosystems. The agriculture sector is the largest user of freshwater. Thus, it is responsible for water withdrawals (Wisser et al., 2024). Consequently, overuse of water in this sector can diminish local water sources, which can reduce water availability in water-scarce regions. Moreover, over-irrigation can lead to salinization, which would degrade soil quality and reduce agricultural productivity resultantly (Karimzadeh et al., 2024). Besides, water drainage containing salinization can also pollute rivers and canals. Monocropping is another reason for soil degradation and erosion, which can reduce soil fertility and productivity. Besides, conventional agricultural techniques could reduce soil organic matter (Mihelič et al., 2024), which could reduce the capacity of soil to hold water and nutrients. Thus, monocropping and conventional agricultural techniques could reduce soil productivity.

4. The Potential Positive Environmental Aspects of Agricultural Activities

Sustainable practices in agricultural activities could have environmentally friendly effects. Figure 2 shows the expected positive environmental effects of the agriculture sector. For instance, agroforestry and planting trees and shrubs in farming would help in reducing CO_2 emissions from the atmosphere (Roghan et al., 2024). Besides, cover cropping can also mitigate GHG emissions, which can improve soil fertility and reduce the need for pollution-oriented fertilizers. Likewise, rotating crops can increase nutrient cycling, which would increase soil productivity and reduce soil erosion (Kumari et al., 2024). This practice could also decrease the need for chemical fertilizers and control potential pollution. Besides, conservation tillage can increase soil organic contents (Gancone et al., 2022). Thus, it could also help in improving soil structure and water retention. Moreover, enhancing feed quality for livestock can reduce methane emissions. In addition, biogas production from agriculture waste could reduce methane emissions from manure and other organic waste (Wang et al., 2024). On the whole, composting agricultural waste and producing biogas would help promote environmental health. Besides, composting crop residues and manure could help in reusing nutrients back into the soil, which would also reduce the need for fertilizers.

Figure 2. Positive environmental effects of the agriculture sector

The optimal use of agricultural inputs, like water, fertilizers, and pesticides, could control water pollution. Moreover, organic farming, relying on natural factors, could reduce chemicals in water sources. Likewise, implanting riparian buffers on the waterways could help to reduce water pollution (Akter et al., 2024). In addition, wetlands comprise natural water purifying, which would be helpful in water management and also protect various species. Besides, drought-tolerant crop varieties and precision and drip irrigation could reduce over-irrigation and preserve water resources, which can reduce the risk of salinization and waterlogging as well (Lakhiar et al., 2024). Moreover, drip irrigation has also the potential to reduce N_2O emissions by reducing fertilizer application. Furthermore, rainwater harvesting could reduce the usage of ground and surface water. Thus, it helps preserve water resources. Integrated pest management can reduce the usage of chemical pesticides, which could also reduce air pollution. Beside. The covered manure storage would mitigate ammonia from livestock (Yan et al., 2024), which could reduce PM2.5 formations as well.

Biodiversity management is a potential source of soil health. For instance, bees and butterflies are potential pollinators and maintain ecosystem balance, which can also enhance crop yields and reduce the usage of chemical inputs. Thus, preserving natural habitats, like maintaining hedgerows, field margins, and woodlots, would support wildlife in the farms and could reduce habitat fragmentation. Thus, this practice could augment biodiversity and ecosystem amenities. Moreover, assimilating native plants, reinstating degraded lands, and using organic matter in the soil can increase soil health and reduce pollution as well (Blanco-Canqui, 2024). In addition, the agriculture sector can reduce its environmental footprint by reducing the usage of fossil fuels in agricultural mechanization. Therefore, using solar, wind, and biomass energy in farms can decrease GHG emissions (Khaleel et al., 2024; Peng et al., 2024). Furthermore, increasing energy efficiency in the agriculture sector can reduce overall fuel consumption and emissions, which could help in mitigating environmental problems in the agriculture sector.

Moreover, the literature also discussed modern sustainable practices. For instance, precision agriculture with the help of drones and sensor technology can monitor crop conditions, soil health, and water, fertilizers, and pesticide needs, which helps to reduce waste and environmental impact and improve yield (Dusadeerungsikul & Nof, 2024). Moreover, genetic advancements would innovate crops with better resistance to pests, diseases, and climatic stresses, which can reduce the need for chemical inputs consequently (Husaini & Sohail, 2024). The usage of biologically engineered fertilizers and biofertilizers would reduce the reliance on synthetic nitrogen fertilizers and also help in improving soil health (Alzate Zuluaga et al., 2024). The usage of biodegradable mulch in crop protection would conserve moisture and reduce the need for chemical herbicides. Moreover, vertical farming relies on hydroponics and aquaponics atmospheres (Parameswari et al., 2024), which help reduce usage of water and land and also eliminate the need for pesticides. In addition, biological pest control systems using natural predators and pathogens for pest control would reduce reliance on chemical pesticides.

5. Literature Review of Macroeconomic Empirical Studies

Aydoğan & Vardar (2020) investigated Emerging Market Seven (E7) countries from 1990-2014 and found that Agriculture Value Added (AVA) and income increased CO_2 emissions. Florea et al. (2020) investigated 11 European countries from 2000-2017 and found feedback between AVA and income and unidirectional influence from AVA to GHG emissions and Renewable Energy Consumption (REC). These findings emphasized the pleasant effect of agriculture on economic and environmental outcomes in the economies. Adedoyin et al. (2020) scrutinized African economies from 1980-2014 and revealed that AVA reduced CO_2 emissions. However, Gross Domestic Product (GDP), urbanization, and natural resources raised them. Wang et al. (2020) assessed the Group of Seven (G7) countries from 1996-2017 and reported that globalization and natural resources increased carbon emissions. However, AVA decreased them. Simionescu (2021) examined the EU's new member states from 1990-2019 and substantiated an inverted N-shaped relationship between GDP and GHG. However, AVA had an N-shaped effect on GHG.

Sharma et al. (2021) investigated the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) nations and found a U-shaped effect of AVA on GHG emissions. Moreover, human capital and pesticide usage influenced emissions differently, and REC reduced pesticide use. Rehman et al. (2021) examined Asian countries from 1996-2014 and found that export diversification, REC, and regulatory quality reduced GHG emissions. However, AVA contributed to higher emissions. Adedoyin et al. (2021) examined E7 economies from 1990-2016 and found agricultural development and income accelerated CO_2 emissions. However, REC reduced emissions. The causality analysis demonstrated feedback between emissions and agricultural development.

Anser et al. (2021) analyzed 26 European economies from 2000-2017 and found the increasing influence of agriculture on emissions in quantile analyses and agriculture technology-based Environmental Kuznets Curve (EKC) was also supported. Moreover, exports and R&D reduced carbon emissions, but trade increased emissions. Nguyen et al. (2021) investigated agricultural emissions in 89 economies from 1995-2012 and found that income, trade, and FDI were responsible for higher agricultural GHG emissions. Moreover, income, AVA, and energy usage increased emissions. Ali (2021) investigated West African countries from 1990-2015 and revealed a unidirectional influence of AVA and REC on CO_2 emissions. A bidirectional relationship was also identified between agricultural development and trade. Ferreira et al. (2022) analyzed Brazil, Russia, India, China, and South Africa (BRICS) from 2005-2018 and revealed that sectoral income positively impacted CO_2 emissions in the industrial sector but had negative impacts on the commercial and public utilities sectors. Moreover, the agriculture and forestry sectors had an inverted U-shaped effect on emissions. Usman et al. (2022) explored South Asian countries from 1995-2017 and found that AVA, economic progress, non-REC, and tourism raised emissions. However, REC showed some mitigation potential.

Makutėnienė et al. (2022) examined the Baltic States from 1998-2019 and found the agriculture-EKC in Lithuania and Estonia. Thus, AVA had a non-linear effect on emissions. Wang et al. (2022) analyzed South Asian countries from 1990-2018 and found that AVA and globalization contributed to CO_2 emissions. However, REC reduced emissions. Omri & Saidi (2022) examined MENA and found feedback between AVA and emissions, and REC mitigated emissions. The industrial sector was found to be the largest contributor to CO_2 emissions. In addition, the feedback effect was also substantiated between CO_2 emissions, REC, and non-REC. Majewski et al. (2022) investigated 94 middle-income nations from 2000-2015 and substantiated that REC and AVA mitigated CO_2 emissions. Abbasi et al. (2021) analyzed 22 top forested countries from 1980-2019 and revealed that increasing AVA and forest areas mitigated CO_2 emissions. However, decreasing AVA and forest areas accelerated CO_2 emissions. Czyżewski & Michałowska (2022) investigated Visegrad Group countries from 2008-2019 and found that AVA and economic progress raised GHG emissions. In comparison, Hungary was carrying the highest eco-efficiency in GHG emissions per unit of AVA. However, Poland performed at the lowest level. Batmunkh et al. (2022) investigated Central Asian countries from 1994-2019 and revealed that AVA and natural resources increased CO_2 emissions but agricultural exports mitigated CO_2 emissions.

Satrovic et al. (2022) explored Southeastern Europe from 1996-2016 and found that increasing agricultural production accelerated pollutant emissions. The bidirectional causality was also validated between emissions and agriculture production. Sui (2023) explored Asian countries from 1970-2020 and AVA and the industrial sector exacerbated environmental damage. Moreover, the EKC was also validated, and REC reduced pollution. Fida & Saeed (2023) examined the EU from 1995 to 2020 and revealed that AVA raised GHG emissions. However, industries, supported by REC and technological advancements, reduced emissions. Han et al. (2023) investigated emerging nations and found that AVA and economic progress contributed to CO_2 emissions. Moreover, oil rents and REC reduced emissions. Ajam et al. (2023) explored developed countries from 1995-2017 and revealed that AVA and globalization mitigated CO_2 emissions. Karimi et al. (2023) investigated the 15 developing nations from 2004 to 2020 and found that AVA raised CO_2 emissions. Additionally, energy usage and trade openness also raised emissions.

Zafeiriou et al. (2023) examined the deforestation and agricultural income-related EKC in Eastern European countries and found an N-shaped EKC. Thus, both variables showed a non-linear relationship with carbon emissions. Gao & Fan (2023) explored Belt and Road Initiative (BRI) nations from 1999-2018 and found that economic progress and AVA exacerbated carbon emissions. Interestingly, the manufacturing and service industries mitigated carbon emissions. Saidmamatov et al. (2023) examined Central Asian countries from 1992-2020 and found that economic progress, water productivity, and electricity production increased CO_2 emissions. Conversely, AVA and trade openness reduced CO_2 emissions. Singh & Dhiman (2023) examined European regions from 2000-2018 and found a feedback effect between AVA and CO_2 emissions in these regions. The same results were found for service, manufacturing, and resource-extensive sectors. Kou et al. (2023) investigated the globe from 1991-2016 and found that the agriculture sector raised global trade-related emissions. The same findings were reported for other economic sectors.

Brankov (2023) investigated the Western Balkans and found that AVA reduced N_2O emissions and raised methane emissions. However, trade reduced both N_2O and methane emissions, and energy usage increased them. Naseem et al. (2023) explored eight major remittance-receiving countries from 1990-2021 and reported that remittances and the agricultural sector mitigated CO_2 emissions. However, financial development and GDP degraded environmental quality. Ali & Guo (2023) investigated Asia from 1975 to 2020 and found that globalization and AVA raised ecological footprints and carbon emissions. Conversely, REC mitigated these environmental impacts. Li et al. (2023) explored Asian countries and reported that AVA and globalization raised ecological footprints and REC played a crucial role in reducing them. The study also validated the EKC. Moreover, the feedback effect was corroborated between AVA and ecological footprint. Padhan et al. (2023) analyzed the BRICS countries and Turkey. The authors revealed that economic progress, AVA, and deforestation exacerbated the ecological footprint. However, REC and eco-innovations contributed to its reduction. Hamed et al. (2024) focused on the MENA region from 1990-2015 and indicated the positive influence of AVA and water productivity on emissions. Suproń & Myszczyszyn (2024) examined 3 Seas Initiative countries from 2008-2020 and found that increasing REC reduced CO_2 emissions. However, economic progress and agricultural productivity were linked to higher emissions. Nesirov et al. (2024) explored Georgia, Ukraine, Azerbaijan, and Moldova from 1996 to 2019 and indicated that agricultural production, forestation, and REC reduced CO_2 emissions.

Table 1. Summary of the empirical literature

Effect of the Agriculture Sector on Pollution	Number of Studies
The agriculture sector increased pollution.	23
The agriculture sector reduced pollution.	10
The agriculture sector had an inverted U-shaped effect on pollution.	2
The agriculture sector had a U-shaped effect on pollution.	1
The agriculture sector had an N-shaped effect on pollution.	2

Table 1 shows the summary of 38 empirical studies on the environmental effects of the agriculture sector in this section. 23 studies corroborated the positive effect of the agriculture sector on pollution. However, ten studies found a negative effect of the agriculture sector on pollution. Two studies reported an inverted U-shaped effect of the agriculture sector on pollution, and one study found a U-shaped effect of the agriculture sector on pollution. Moreover, two studies found an N-shaped effect of the agriculture sector on pollution. The macroeconomic studies provide the guidelines for macroeconomic policies for the agriculture sector. For instance, ten studies reported the pleasant environmental effects of the agriculture sector, and most of these studies were conducted for developed economies, which are expected to use modern sustainable agriculture practices. Thus, these practices have the potential to have pleasant environmental effects in this sector. However, 23 studies have reported that increasing the agriculture sector could cause environmental problems. Thus, the investigated economies should adopt sustainable practices in the agriculture sector to avoid environmental problems. Moreover, the evidence of an inverted U-shaped or U-shaped relationship between the agriculture sector and pollution shows that the agriculture sector up to a threshold point could have pleasant environmental outcomes. Thus, the world economies should limit the agriculture sector to ensure its positive role in environmental sustainability.

6. Discussions and Synthesis

The agriculture sector in any economy could have positive or negative environmental outcomes. For instance, conventional and traditional agriculture practices like monocropping lead to environmental issues and soil degradation. Moreover, the usage of pesticides and herbicides would lead to biodiversity loss and water pollution. Moreover, the agriculture sector is also responsible for freshwater withdrawals. In addition, the usage of fossil fuels for energy needs is responsible for GHG emissions. Furthermore, livestock farming also potentially contributes to GHG emissions. Lastly, expanding agricultural land may lead to deforestation, which is responsible for carbon emissions and biodiversity losses. However, adopting sustainable agricultural practices would reduce environmental and ecological concerns. For instance, agroforestry, cover cropping, and crop rotation can reduce CO_2 and other chemical inputs, which can also improve soil fertility. Some other sustainable agricultural practices, like conservation tillage, could enhance soil health and biogas production from agricultural waste would mitigate GHG emissions. In addition, water-efficient practices like drip irrigation, water storage, and rainwater harvesting could help preserve freshwater resources and reduce salinization. Moreover, vertical farming in the hydroponics and aquaponics atmospheres could reduce the need for water, land, and pesticides. In addition, the biological pest control system also helps reduce the need for chemical pesticides. Modern technologies like precision agriculture with the help of drones and sensors could reduce usage of farm inputs and waste, which could also help to improve crop yield. Similarly, genetic advancements would provide crops with more resistance to pests, diseases, and climatic stresses, and help reduce chemical inputs. Moreover, the usage of biologically engineered fertilizers, biofertilizers, and biodegradable mulch in crop protection would reduce the reliance on synthetic nitrogen fertilizers and herbicides, and also improve soil health.

The review of macroeconomic panel studies provides mixed evidence of positive, negative, or nonlinear effects of the agriculture sector on the environment. With pleasant environmental effects of the agriculture sector, macroeconomic literature provides evidence that some economies are practicing sustainable agriculture practices to have pleasant environmental effects in the agriculture sector. For instance, pleasant environmental effects of the agriculture sector are mostly found in developed economies, which are expected to use higher environmental standards in agriculture production and more sustainable agricultural practices. However, the literature also corroborates that some economies are not mature enough in their agriculture sector and the agriculture sector in these economies has environmental problems. Therefore, those economies with environmental problems in the agriculture sector need to adopt sustainable agriculture practices. In addition, the literature has also investigated and substantiated the nonlinear effects, inverted U-shaped, U-shaped, or N-shaped, of the agriculture sector on pollution. These studies provide evidence that economies should find a threshold point for their agriculture sector size to have the pleasant environmental effects of this sector.

7. Conclusions

The world population is growing rapidly and putting pressure on the agriculture sector to meet the food demand.

However, the agriculture sector could have environmental problems. Thus, the present research aims to review the literature inquiring positive and negative environmental effects of the agriculture sector. Moreover, the studies on the environmental effects of the agriculture sector are also reviewed to see the macroeconomic effects of the agriculture sector on pollution. For this purpose, the Scopus database is consulted following a systematic review approach, and 70 studies are selected. In the macroeconomic domain, 10 studies have found the pleasant environmental effect of the agriculture sector and 23 studies have corroborated the adverse environmental effect of the agriculture sector. In the remaining studies, 2, 1, and 2 studies found an inverted U-shaped effect, the U-shaped effect, and the N-shaped effect of the agriculture sector on pollution, respectively.

In the negative environmental effects of the agriculture sector, the literature shows that the agriculture sector is responsible for GHG emissions, soil and water pollution, deforestation, water scarcity, and soil degradation. These environmental effects stem from the usage of fertilizers, herbicides, pesticides, fossil fuels, and monocropping. For instance, the use of fossil fuels in the agriculture sector could increase carbon footprints and GHG emissions. Further, methane is mostly released from manure management and animals' digestion. Besides, the usage of fertilizers, herbicides, and pesticides is responsible for N_2O emissions and other toxins in the soil and water. Furthermore, waste generation from the whole agriculture supply chain can be responsible for water pollution and GHG emissions. Monocropping and conventional farming could reduce soil organic matter, which could be responsible for soil degradation. In addition, deforestation to increase agricultural land would reduce carbon sinks, could damage biodiversity, and upset the balance of the ecosystem. The stress on global freshwater resources is another consequence of the agriculture sector, as this sector is the largest user of freshwater and is responsible for freshwater withdrawals. To moderate the adverse environmental effects, the literature has suggested cover cropping, conservation tillage, agroforestry, integrating native plants, restoring degraded lands, crop rotation, and organic farming to enhance soil productivity, reduction in chemical usage, and promotion of biodiversity. Moreover, increasing agricultural productivity, by optimizing the use of water, fertilizers, and pesticides, can help this sector reduce ecological and environmental problems. The improved livestock feed quality and bioenergy generation from crop residues and animal waste would help in reducing GHG emissions. Replacing renewable energy with fossil fuels and increasing overall energy efficiency can also help reduce environmental problems in the agriculture sector. In addition, some modern technologies could help improve the environmental performance of the agriculture sector. For instance, precision agriculture with the help of drones and sensors could reduce usage of farm inputs and improve crop yield. Similarly, genetic advancements can help crops resist pests, diseases, and climatic stresses, which can reduce the usage of chemical inputs and environmental problems. Further, biologically engineered fertilizers, biofertilizers, and biodegradable mulch could reduce the dependence on synthetic nitrogen fertilizers and herbicides, which can reduce pollution and improve soil health.

Based on findings, the present research suggests adopting sustainable farming practices, which would reduce environmental problems and increase agricultural productivity as well. For instance, governments should promote agroforestry, crop rotation, conservation tillage, and organic farming. Moreover, governments should initiate training programs for farmers to promote sustainable practices in the agriculture sector. Besides, environmental standards should also be improved to discourage harmful chemicals in fertilizers and pesticides, which could reduce soil and water pollution. Furthermore, an integrated pest management system should be promoted to minimize the usage of synthetic herbicides, pesticides, and fertilizers, which will also promote a healthier natural ecosystem. The farmer should invest in livestock diet technologies and manure management systems to reduce methane emissions. Chemical fertilizers should be replaced with organic alternatives and biofertilizers, and biological control methods should be encouraged to reduce the use of pesticides. Moreover, genetically modified advanced crops with better resistance to pests, diseases, and climatic stresses should be promoted. Drip irrigation and rainwater harvesting techniques should be encouraged to reduce freshwater withdrawals. To reduce the pollution from fossil fuels in the agriculture sector, governments should give financial and non-financial support to install renewable energy sources in this sector. For instance, solar-powered irrigation systems, wind turbines, and biogas from animal waste in farms could transfer the energy needs from fossil fuels to renewable sources. The bioenergy production from crop residues, manure, and other agricultural waste could have a great potential to reduce the dependence on fossil fuel energy needs in the agriculture sector. Moreover, governments should invest in R&D activities to improve energy efficiency in the agriculture sector. Besides, deforestation to increase agricultural land should be discouraged to maintain the carbon sinks and biodiversity in the forest areas. Moreover, the native plantations on farms should be encouraged to enhance biodiversity and soil quality. Moreover, the adoption of precision agriculture techniques with the help of drones and soil sensors is recommended to reduce the usage of water, fertilizers, and pesticides, reduce waste and environmental impact, and improve soil health and agriculture yield.

Author Contributions

Conceptualization, H.M. and M.S.H.; methodology, H.M. and G.M.; validation, H.M. and M.S.H.; investigation, H.M. and M.S.H.; resources, H.M.; data curation, M.F.; writing—original draft preparation, H.M., M.F. and

M.S.H.; writing—review and editing, H.M., M.F., G.M. and M.S.H.; visualization, H.M.; supervision, H.M.; project administration, H.M.; funding acquisition, H.M. All authors have read and agreed to the published version of the manuscript.

Funding

The authors extend their appreciation to Prince Sattam bin Abdulaziz University for funding this research work (Grant No.: 2024/RV/03).

Data Availability

Data sharing is not applicable as the study is a review article.

Conflicts of Interest

The authors declare no conflict of interest.

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