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Agriculture supply chain management and environmental sustainability in Alkharj: Moderating role of economic and social sustainability

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The agriculture sector and other agribusinessescan have a long-lasting effect on the environment. The present studyinvestigates the effect of Agricultural Supply Chain Management (ASCM), fromproducer to consumer, on Environmental Sustainability (ES) in the Alkharj governorateby collecting primary data from 312 respondents in the ASCM in Alkharj and byapplying Structural Equation Modelling (SEM). Moreover, the moderating roles ofeconomic and social sustainability in the nexus between ASCM and the ES arealso tested. The results of the analyses show that ASCM directly improves theES in the agriculture sector. Moreover, ASCM also improves both economic andsocial sustainability. Consequently, economic and social sustainability improvesthe ES. Thus, economic and social sustainability have positively moderated therelationship between ASCM and the ES. The results suggest that the governmentof Alkharj governorate should further improve the economic sustainability ofagribusinesses in Alkharj by providing incentives. Moreover, education andtraining programs should be initiated to improve social sustainability. Thus,both improved social and economic sustainability of agribusinesses could encouragesustainable practices to promote the ES in the whole ASCM in Alkharj.

1. Introduction

Alkharj governorate is located in the center of Saudi Arabia with 376 thousand residents as per the 2010 population census and carries arid land with some sustainable agricultural facilities. The region is famous for dairy, poultry, and various food crops and contributed to the national food supply chain in a significant amount. For instance, it contributes 65 percent of the total milk produced in the Kingdom by top Saudi food production businesses and 26% of the vegetables produced in the Kingdom come from Alkharj governorate (General Authority for Statistics, 2024). Thus, it is home to the biggest dairy farms and other agricultural activities. The Agricultural Supply Chain Management (ASCM) in Alkharj includes various stages from input supply and farming to processing, distribution of agriculture products, and retail as well.

An effective ASCM is crucial in Alkharj governorate to supply agricultural products efficiently from producers to consumers in the whole supply chain maintaining the quality of the product and reducing the waste as well, which needs the coordination of many stakeholders, i.e., farmers, processors, distributors, wholesaler, retailers, consumers, policy-makers, etc. Agriculture sector, like other economic sectors, is not out of environmental problems and can be responsible for environmental degradation if environmentally friendly technologies are ignored in all ASCM. For instance, the use of chemical substances can damage soil health and can be responsible for Greenhouse Gas (GHG) emissions (Xing et al., 2023). Moreover, wastewater and waste residue can result in water and solid pollution. Moreover, farm machines and transport vehicles are another source of environmental degradation if fossil fuels are utilized for their energy needs (Yasin et al., 2024). Therefore, the global agriculture sector realizes the importance of green ASCM for Environmental Sustainability (ES) in the agriculture sector.

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The ES may include all practices to reduce any environmental consequences of agricultural activities. For instance, GHG emissions from all agriculture supply chains should be reduced by promoting Renewable Energy Consumption (REC) for energy needs, optimizing transportation and logistics in all agriculture distribution channels, and increasing energy efficiency in all agriculture supply chains from production to distribution (Baldos et al., 2023). Moreover, environmental problems of farming might be reduced by adopting natural fertilizer, reducing the use of chemical fertilizer, adopting precision farming techniques, integrating pest management systems, increasing overall agriculture productivity, minimizing the waste out of all agricultural activities, by adopting environmentally friendly processing technologies for all agriculture products, and by ensuring the presence of bio-diversity in croplands to sustain a healthy agricultural environment. Thus, the agriculture sector should use circular economy practices in all ASCM to conserve natural resources for future generations and to promote ecological balance. Particularly, sustainable agricultural practices are very important for Alkharj due to the vulnerability of the governorate in terms of water scarcity and climate variability. Thus, the region needs more ES practices for long-term sustainability in its agriculture sector.

While caring about the environmental issues in the agriculture sector, we cannot ignore the economic and social aspects of the ASCM system (Wei et al., 2022). The economic and social responsibilities of the agriculture sector can even support the ES in all ASCM. In the social responsibilities, the agriculture sector should provide social welfare to the local community with a high-quality food supply to protect consumer health and by charging fair prices for agricultural products to ensure a sufficient consumer surplus by increasing the gap between satisfaction from agricultural products and prices of these products (Song et al., 2022). Thus, social indicators of ASCM would motivate the consumers to actively cooperate in the ES issues of the agriculture sector. At the same time, social responsibilities also include protecting labor rights. For instance, reasonable wages for agriculture labor and safe working conditions can win the confidence of agriculture laborers to be actively involved in ES practices to promote the slogan of green ASCM (Sazvar et al., 2018). Moreover, the rights of agriculture producers and distributors cannot be ignored, which are termed as economic sustainability of green ASCM. For instance, there should be a reasonable profit from agriculture businesses to finance sustainable practices in agricultural activities. For this purpose, costs and risks associated with all ASCM should be controlled at optimal levels to increase the profit of the agriculture business community by adopting cost-saving measures like optimized inventory management, decreasing packaging wastages, and utilizing modern technologies to monitor ASCM efficiency. Thus, cost efficiency and management of resources can provide reasonable profits to the agriculture business community to adopt ES practices in the agriculture sector.

Keeping in mind the above discussions, there is a need for a comprehensive survey of ASCM and ES issues in the Alkharj governorate to identify the current practices in ASCM and ES. Understanding the key issues of all stakeholders of ASCM can identify the areas for improvements for policy perspective to implement sustainable ASCM practices. Thus, the present study has surveyed stakeholders of ASCM, i.e., farmers, distributors, retailers, and policy-makers, in the Alkharj governorate to investigate the relationship between ASCM and ES in the Alkharj agriculture sector. Moreover, the social and economic sustainability of green ASCM practices would play an active moderating role in the relationship between ASCM and ES in Alkharj. Thus, the present research has also surveyed the indicators of social and economic sustainability of green ASCM to find their moderating role in the relationship between ASCM and ES. Hence, our findings might contribute to the agriculture literature of Alkharj by providing empirical evidence and practical insights to promote sustainability in ASCM in the Alkharj governorate.

2. Literature Review

There is a diverse range of literature available on the topic. The present study has included those studies in this literature review, which are focusing on the environmental aspects of the agriculture sector's supply chain. Hou et al. (2024) highlighted the expected impact of digitalization on the agriculture sector's ecological transformation in China and disclosed a nonlinear effect of innovation on ecological footprints. In another study, Ntiamoah et al. (2024) discussed Greenhouse Gas (GHG) emissions in West Africa and argued that there is a need for a multidisciplinary approach to reduce emissions and to make sure of food security issues at the same time. On the input side, Xiao et al. (2024) explored the water efficiency and pollution reduction strategies in agricultural systems and suggested integrated crop-livestock systems to reduce environmental problems in the agriculture sector. In the same manner, Ye et al. (2024) investigated Chinese agricultural CO2 emissions and proposed CO2 emissions mitigation tactics in the Fujian Province in China. In another study in China, Zhou (2024) examined the effect of digitalization on agricultural CO2 emissions in China and suggested several policy recommendations to ensure a green transformation.

Considering spillovers of the agriculture sector, Meng et al. (2024) analyzed the spatiotemporal relationship of crop-mix strategies in China to reduce carbon emissions and suggested crop-mix strategies for sustainable agriculture development without harming the environment. Similarly, Zheng et al. (2024) analyzed the spillovers of agricultural CO2 emissions among 31 Chinese provinces and suggested green policies to mitigate the environmental problems in the local and neighboring provinces to promote sustainable agricultural development. Jacquet et al. (2023) investigated emissions in the agribusiness sector in Benin. The authors found the spatial dimensions of N2O emissions in the nearby-located regions. Moreover, population density and education levels were inducing agribusiness emissions. Thus, the authors suggested many green policies to mitigate emissions to reduce the climate change effect of the agriculture sector.

In another spatial study, Amorim et al. (2023) investigated the convergence of GHG emissions in different states of Brazil and their analysis found that different convergence clubs were responsible for spillovers of GHG emissions. Particularly, CO emissions were reduced in all clubs. However, the reduction of CO2 emissions was limited in most of the clubs. Their findings provided insights into the spillovers of GHG emissions in Brazil to target policies to mitigate emissions in local and neighboring states of Brazil. Wu et al. (2023) analyzed the spatial linkages in agriculture emissions in Anhui and found that promoting low-carbon policies helped to accelerate sustainable agricultural development. Moreover, spatial spillovers were also found in the agriculture emissions, which provided valuable insights to formulate policies promoting sustainable agricultural growth in the province. Wei et al. (2023) explored spatial effects in the agriculture emissions in Northeast China and found the spatial dynamics in agriculture emissions. Thus, the findings suggested a need for systematic interventions to achieve agricultural carbon reduction for the sustainable agriculture sector. Su and Wang (2023) explored the spatial relationship between digital financing and carbon intensity in the Chinese agriculture sector. In the spatial analysis, the author found that digital financing helped reduce the agriculture sector's carbon intensity in local and neighboring regions. Moreover, digital financing helped mitigate agriculture emissions in the whole region.

Yasin et al. (2024) investigated the influence of forest rents, agricultural sector, income, and energy usage on emissions in BRICS nations and suggested a green transformation in the agriculture sector to mitigate environmental problems. Xu et al. (2024) investigated the Chinese methane emissions in rice crops and livestock dung in China and found that both activities were pollution-oriented in the investigated Chinese provinces. Thus, the authors suggested provincial-level emission reduction strategies. In another Chinese study, Ma et al. (2024) examined methane mitigation and found that water-fertilizer coupling management helped reduce methane emissions in rice crops and suggested region-specific strategies to mitigate the emissions. Focusing on the rice sector, Wang et al. (2024) analyzed the rice supply chains in China and proposed potential suggestions to mitigate emissions in the rice supply chain to build sustainable food systems under global warming.

Wang et al. (2023) explored GHG reduction in Dutch dairy farms through land optimization. The authors found that a circular agriculture mechanism would help mitigate substantial emissions in dairy forms. Alavijeh et al. (2023) scrutinized the nexus between the agricultural sector and CO2 emissions in the 15 top-populated poor countries from 2004-2020 and found that agricultural income had a positive effect on CO2 emissions in quantile analyses. Moreover, a stronger effect was observed in higher quantiles. Energy usage and trade openness also raised CO2 emissions in upper quantiles. Moreover, the income and population of the country also had positive effects on emissions. Chandio et al. (2023) examined grain production to ensure food security and poverty reduction in China from 1990-2017. The authors found that agricultural research spending improved grain crop yield. Moreover, agricultural credit also helped raise grain crops. However, CO2 emissions had a negative impact on grain crop output but fertilizer usage increased grain crop production. Their findings suggested that financial support to R&D and access to agricultural credit could increase to support agricultural products. However, the policies should also be designed to mitigate CO2 emissions.

Raihan (2023) examined the effect of agriculture on climate change in Vietnam from 1984-2020 and found that income and energy usage contributed to CO2 emissions. However, the agricultural sector reduced Vietnam's emissions. Nasseri (2023) explored the role of crop inputs' optimization in reducing energy input and GHG emissions. The author found that wheat farms reduced energy input, enhanced energy productivity, and helped in reducing CO2 emissions. Aziz and Chowdhury (2022) investigated the agribusiness GHG emissions in Bangladesh from 1990-2014 and found that population and urbanization contributed to CH4, CO2, and N2O emissions. However, agricultural mechanization increases such emissions, which should prioritize clean energy to reduce emissions.

Sampedro et al. (2023) analyzed the CH4 emissions from the agriculture sector and projected the marginal agricultural damages globally and by region to evaluate ozone-related damages to crop revenues. Their findings confirmed the environmental damage and suggested strategies to reduce CH4 emissions by considering cost-benefit analyses of the agriculture sector. Aluwani (2023) examined REC, CO2 emissions, and trade nexus in the agriculture sector in South Africa from 1990-2021 and found that agricultural sector growth contributed to environmental deterioration. However, trade helped mitigate environmental deterioration in the sector. Moreover, renewable energy also moderated agricultural growth without harming the environment. Thus, the study's findings provide empirical evidence promoting REC and fostering sustainable agricultural outcomes. Li et al. (2023) explored agribusiness in 30 Chinese provinces from 2000-17 and found the Environmental Kuznets Curve (EKC).

Shi et al. (2023) examined China from 1950-2021 and highlighted a significant environmental challenge from crop straw management. The authors found that straw utilization had transitioned from open burning to retention in fields. But, this shift has led to increased GHG emissions. Their study recommended a potential to convert unnecessary straw utilization into bioenergy to mitigate GHG emissions effectively. Martín-Ortega and González-Sánchez (2023) investigated the EKC in the industrial, service, and agriculture sectors of the EU from 1990 to 2018. Their findings confirmed the presence of EKC in a few sectors and delivered the importance of sector-specific policies to mitigate GHG emissions. Herrera et al. (2023) explored the EU and identified that environmental objectives, farmer experience, and education could promote a clean environment. Moreover, their study found that institutional support in a circular agriculture economy would promote sustainable farming practices.

Guo et al. (2023) examined China and found that using the circular economy concept in the agriculture sector would help mitigate carbon dioxide emissions through green and low-carbon agricultural development and suggested some valuable policies mitigating emissions. Xie and Wu (2023) explored and found that economic integration mitigated emissions' efficiency with the help of low-carbon technologies in China from 2005-20. Moreover, the study highlighted the importance of regional economic development to enhance agricultural emissions' efficiency. Baldos (2023) projected the R&D investment in the USA to reduce agribusiness GHG emissions from 2025-35. The results indicated that increasing R&D investments in US agriculture would reduce GHG emissions in the USA. Thus, R&D policies clubbing with the farm inputs could raise productivity and environmental sustainability in the agriculture sector at the same time for a dual benefit from this investment.

Balogh (2023) examined agricultural GHG in the EU and found that agricultural subsidies increased agricultural-related emissions. However, organic substances mitigated emissions. Thus, the study recommends the organic substances' plan to reduce GHG emissions in the EU states. Taridala et al. (2023) studied the Indonesian efforts to mitigate agribusiness emissions using a dataset from 30 provinces from 2006-2020 and found that green finance and innovation in agriculture reduced carbon intensity in this sector. Their findings suggested mitigating carbon intensity through REC and green financing for a more sustainable and low-carbon economy. Sarfraz et al. (2023) analyzed the CO_2 and CH_4 emissions in the Chinese agricultural sector from 2000 to 2021 and found a strong correlation between CO_2 emissions and R&D and between CH_4 emissions and the agricultural sector. Xing et al. (2023) examined a sustainable food system in Fujian, China, and identified that crops, livestock, and aquaculture enhanced nitrate emissions and suggested that a circular agricultural system with nitrate recycling would help mitigate emissions in Fujian's agricultural sector. Bell et al. (2023) explored tomato distribution schemes in the United States, which helped to minimize GHG emissions from the transportation of tomatoes. The authors identified that optimal distribution patterns and reallocations of markets could substantially reduce emissions from this transportation. Their findings displayed geographic conditions in determining GHG emissions, which would be optimized for improving the environmental sustainability of food distribution systems.

Khurshid et al. (2022) investigated Pakistan's agriculture and found asymmetrical relationships between agricultural production and CO_2 emissions. The positive shocks in production had accelerated emissions and negative shocks had mitigated the emissions. Surprisingly, trade and urbanization had negative effects on CO_2 emissions with rising globalization. Thus, it could be targeted for sustainable agricultural practices to mitigate CO_2 emissions. Wang et al. (2022) explored N_2O emissions from tea plantations and found that tea contributed to such emissions. Thus, adopting green agricultural practices should be targeted to mitigate emissions and enhance the sustainability of tea production systems as well. Kapa et al. (2022) probed the effects of green financing on agriculture pollution in 6 major emitting countries and reported the negative nexus between green financing and emissions. However, population and economic growth showed positive effects on emissions.

Yoon et al. (2022) scrutinized the water-energy-food-carbon nexus and found that heating temperature increased emissions. Thus, resource management could improve climate change scenarios with efficient resource management strategies to mitigate the impacts of temperature change on agricultural productivity and climate. Majewski et al. (2022) examined REC, agricultural growth, and CO_2 emissions nexus in middle-income countries from 2000-15 and found that REC and agricultural growth reduced CO_2 emissions. Stetter and Sauer (2022) examined Bavaria from 2005-14 and found significant gaps in farm-level emissions and emission efficiencies. Wade et al. (2022) explored GHG emissions in the US agriculture and forest sectors. Their results displayed that those forests contributed to carbon sequestration, which realized the priority of the policies to reduce emissions and to keep storing carbon in land use systems.

Rehman et al. (2021) analyzed GHG emissions forecasting in the agriculture sector from 1990-2016 in Pakistan. Their findings suggested that industry and land-use change contributed to GHG emissions and forestry reduced GHG emissions. Nguyen et al. (2020) investigated the agricultural emissions in 89 economies from 1995-2012 and found that income, agriculture sector, energy usage, and economic integration raised emissions. However, Foreign Direct Investment (FDI) had negative effects on emissions. Ali et al. (2021) explored the influence of innovation, energy usage, and bio-capacity on emissions in Nigeria from 1981-2014 and confirmed the EKC in this economy. Agricultural innovation and energy raised emissions and income and bio-capacity had emission-reduction effects. Azwardi et al. (2021) scrutinized the impact of motor vehicle emissions on pollution in 33 Indonesian provinces from 2010-17 and found that agricultural and forest areas improved the air quality index. Cai et al. (2021) analyzed CO_2 emissions in South Asia from 1990-2018 and found that the REC and agriculture sector mitigated CO_2 emissions. However, non-REC and urbanization accelerated CO_2 emissions and the EKC was also confirmed. Ridzuan et al. (2020) investigated CO_2 emissions in Malaysia from 1978-2016 and found that CO_2 emissions increased because of increasing income and urbanization. However, livestock could not affect CO_2 emissions but crops, fisheries, and REC mitigated CO_2 emissions in Malaysia. Pazienza and De Lucia (2020) analyzed the effect of FDI in agriculture on CH_4 emissions and found that FDI in agriculture and fishing sectors mitigated CH_4 emissions. Thus, FDI served for technology transfer to promote allocative efficiency, which could help reduce environmental impact in the agriculture and fishing sectors. The reviewed literature signified that the agriculture supply chain could determine the environmental quality in the agriculture sector and the whole economy. Thus, the present study is motivated to find the net environmental consequences of the ASCM in Alkharj, which is an agriculture hub of Saudi Arabia.

3. Methodology

To gather the data on the ASCM, a questionnaire is developed consisting of six items on ASCM, four items on environmental sustainability, three items on economic sustainability, and two items on social sustainability. ASCM includes all activities ranging from the production of agriculture products, processing after production, and distribution channels from producer to consumer. Environmental sustainability indicators include the reduction in utilization of fertilizers and pesticides, the presence of bio-diversity in croplands, energy utilization and efficiency, and efficient transportation and distribution channels from production to consumer. Economic sustainability indicators are cost efficiency in production, efficient resource management, profitability of agriculture products, and access to finance. Social sustainability is reflected by agriculture labor rights and fair pricing of agricultural products for the local community.

The questionnaire is first written in the Arabic language to ensure the respondents' understanding of the questions and to collect valid responses consequently. The responses are collected on a Likert scale ranging from 1 to 5. 1 shows the lowest expectation of the asked item and 5 reflects the highest expectation of the asked item. The questionnaire is distributed among 500 professionals related to agriculture production and processing units, and agriculture products' distributing channels. Out of 500, 312 valid filled responses were collected and the response rate was recorded as 62.4%. From the collected data, the 4 major constructs are developed, which are ASCM, Environmental Sustainability (ES), Economic Sustainability (ECON), and Social Sustainability (SS). Thus, all items are loaded in the relevant constructs and the reliability of the constructs is investigated by using the CR, AVE, and Cronbach α tests. The constructs are accepted as valid if the estimated statistics of CR and Cronbach α are found greater than 0.7. Moreover, the minimum statistics of AVE is decided at 0.5 and the constructs are accepted as valid if the estimated statistics of AVE are found more than 0.5. After ensuring the validity of the constructs, four models are hypothesized to see the moderating impact of ECON and SS in the association between ASCM and ES by using Structural Equation Modelling (SEM). Model 1 hypothesizes the direct effect of ASCM on ES as follows:

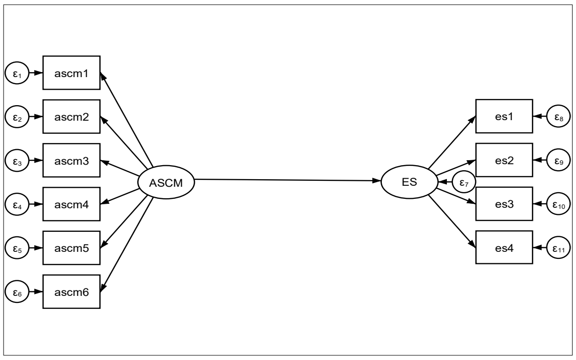

Fig. 1. Model 1

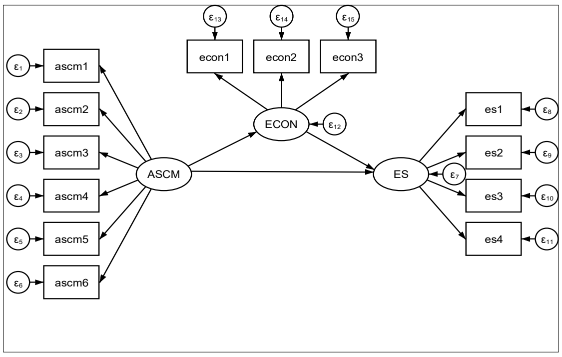

Fig. 2. Model 2

From the Fig. 1, the following hypotheses are generated:

H1: *The ASCM enhances the ES.*

Model 2 is hypothesized to access the moderating impact of ECON in the connection between ASCM and ES as follows:

From the Fig. 2, the following hypotheses are developed:

H2: *The ASCM enhances the ECON.*
H3: *ECON mediates the relationship between the ASCM and the ES.*

To see the moderating influence of SS in the association between ASCM and ES, model 3 is hypothesized as follows:

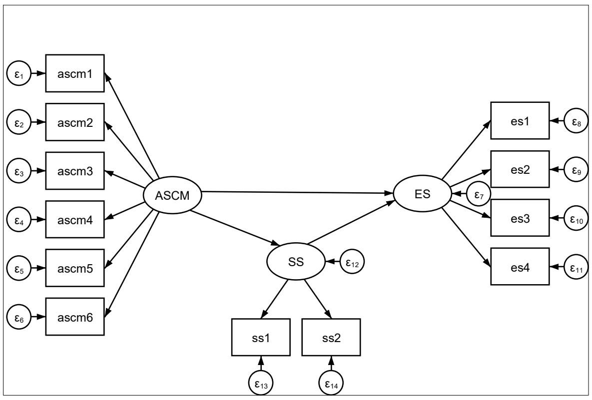

Fig. 3. Model 3

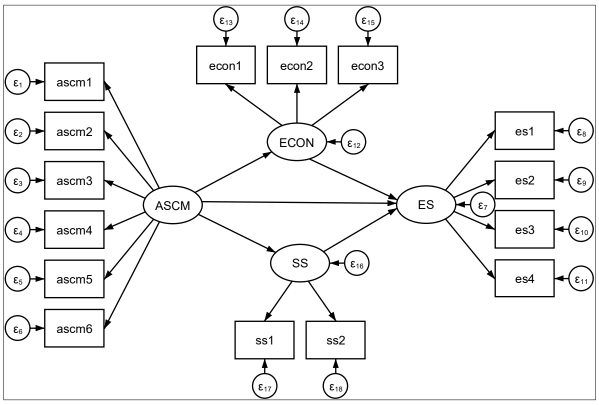

Fig. 4. Model 4

From the Fig. 3, the following hypotheses are generated:

H4: *The ASCM improves the SS.*
H5: *SS mediates the relationship between the ASCM and the ES.*

Lastly, model 4 assumes that both SS and ECON have a moderating impact on the relationship between ASCM and ES. The fourth model is hypothesized as follows:

From the Fig. 4, the following hypotheses are generated:

H6: *The ASCM improves the SS and ECON.*
H7: *Both SS and ECON mediate the relationship between the ASCM and the ES.*

After regressing the four hypothesized models, the fitness of the models will be tested by applying χ^2/df, CFI, TLI, RMSEA, and SRMS tests and following the critical bounds provided by Schermelleh-Engel et al. (2003). The models can be assumed well-fitted if the statistic of χ^2 /df is more than 0 and less than 3. The critical bounds for CFI and TLI are suggested equal to or more than 0.95 and equal to or lesser than 0.97. The critical bounds for RMSEA are suggested equal or more than 0.05 and equal or lesser than 0.08 and the critical bounds for SRMR are suggested equal or more than 0.05 and equal or lesser than 0.10.

4. Data analysis

Table 1 shows the results of CR, AVE, and Cronbach α tests to verify the validity of the constructs after loading their respective items. The estimated values of CR and Cronbach α tests are more than 0.8 in the case of all constructs. Thus, all constructs with their fitted items are reliable. Moreover, the AVE values of ASCM, ES, SS, and ECON are 0.896, 0.815, 0.875, and 0.925, respectively. Thus, 89.6%, 81.5%, 87.5%, and 92.5% of the variation in the constructs of ASCM, ES, SS, and ECON, respectively, are due to respective items of the constructs. Therefore, all tests ensure the validity of ASCM, ES, SS, and ECON.

Table 1
Constructs' Reliability Tests

Constructs	CR	AVE	Cronbach α
ASCM	0.801	0.896	0.933
ES	0.852	0.815	0.898
SS	0.814	0.875	0.867
ECON	0.911	0.925	0.855

Table 2 and Fig. 5 display the results of estimated model 1. The estimated values of diagnostic tests are within critical bounds, which confirms the goodness of fit of model 1. The result shows that ASCM has a direct positive effect on the ES, which validates the H1. Thus, ASCM in Alkharj governorate has proved to be environmentally friendly as per the perception of respondents of the survey.

Table 2
Results of Estimated Model 1

Effect	Coefficient	SE	z-test	p-value
ES←ASCM	1.157	0.407	2.84	0.004
Diagnostic tests				
χ2 /df	2.954			
CFI	0.952			
TLI	0.965			
RMSEA	0.058			
SRMR	0.078			

The results reflect that the agriculture sector in Alkharj utilizes farm resources such as water, fertilizers, and pesticides in an optimal way, which promotes environmental sustainability. Moreover, Alkharj is near to Riyadh, which is the capital city of Saudi Arabia. Thus, expected wastes in all supply chains from producers to consumers are minimal, which might be low due to the lesser chance of storage as the two big markets of Alkharj and Riyadh are near the production place. This advantage also reduces long transportation, which might help in reducing waste and pollution in transportation. Moreover, the overall logistic chain in the ASCM seems to be efficient, which could be helpful in reducing the use of fuel and carbon footprints. Moreover, the administration of Alkharj governorate is supporting the farmers to use sustainable farming practices, which might help in reducing carbon and methane emissions. On the whole, the result shows that ACSM practices are improving environmental sustainability by reducing resource consumption, diminishing waste, mitigating emissions, and encouraging sustainable agricultural practices in the Alkharj governorate.

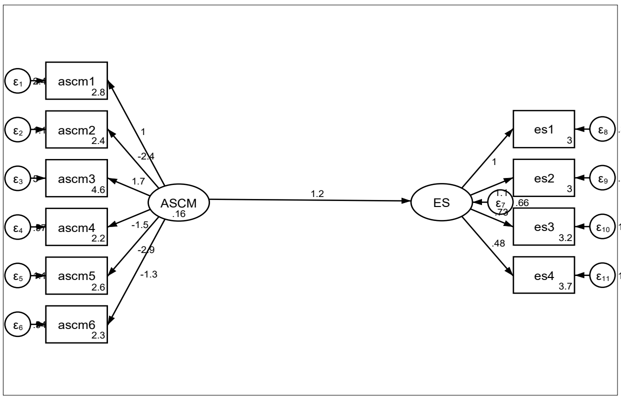

Fig. 5. Estimated Model 1

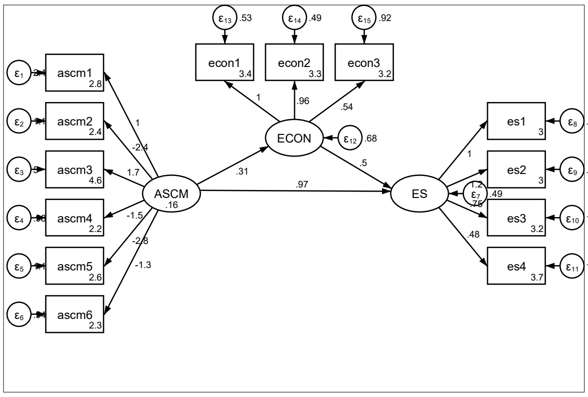

Fig. 6. Estimated Model 2

Table 3 and Fig. 6 display the results of estimated model 2 and the estimated values of diagnostic tests are within critical bounds. Thus, the estimated model 2 is well-fitted. Model 2 is regressed and the results validate the hypotheses H2 and H3. Thus, ASCM improves the economic sustainability of the agriculture sector in Alkharj, which in turn helps to improve the ES.

Table 3
Results of Estimated Model 2

Effect	Coefficient	SE	z-test	p-value
ES←ASCM	0.968	0.336	2.88	0.004
ECON←ASCM	0.312	0.071	4.40	0.000
ES←ECON	0.498	0.094	5.25	0.000
Diagnostic tests				
$\chi2$ /df	1.857			
CFI	0.968			
TLI	0.957			
RMSEA	0.069			
SRMR	0.099			

The results corroborate that businessmen in ASCM get a good amount of profits from ASCM businesses, which helps to increase investment in sustainable practices in the whole ASCM. Thus, economic sustainability confirms that farmers and other agribusinesses have sufficient financial position to invest in sustainable practices like environmentally friendly technologies, irrigation systems, REC, and other eco-friendly resources. Moreover, economic sustainability also gives the capacity to businesses to plan for long-term planning for the ES. With economic sustainability, agribusinesses may have greater access to the market, which in turn gives them better revenues to adopt sustainable practices in their businesses. In addition, economic sustainability would help businesses to invest in recycling programs and managing waste, which would reduce pollution. Last but not least, economic sustainability can help in adopting innovative eco-friendly technologies and would help in getting education and training for sustainable agricultural practices.

Table 4 and Fig. 7 display the results of estimated model 3. The estimated values of diagnostic tests are within critical bounds. Thus, the estimated model 3 is well-fitted. Model 3 is regressed to verify the moderating influence of SS in the nexus between ASCM and the SS.

Table 4
Results of Estimated Model 3

Effect	Coefficient	SE	z-test	p-value
ES←ASCM	0.435	0.123	3.54	0.000
SS←ASCM	0.442	0.182	2.43	0.015
ES←SS	1.616	0.353	4.58	0.000
Diagnostic tests				
$\chi2$ /df	2.254			
CFI	0.955			
TLI	0.967			
RMSEA	0.077			
SRMR	0.088			

ASCM improves the social sustainability of the agriculture sector in Alkharj and SS helps to improve the ES, which validates the hypotheses H4 and H5. Thus, the SS plays a moderating role in assisting the ASCM to improve the ES in Alkharj. The SS promotes the confidence of labor and community in favor of agribusiness. Thus, both stakeholders help the ASCM to achieve the ES. Moreover, the SS improves the awareness of environmental sustainability among the labor and local communities, which supports sustainable practices. Moreover, the SS includes fair labor practices, which make the laborers happy in their work activities and adopt environmentally sustainable practices to reduce environmental degradation in the whole ASCM.

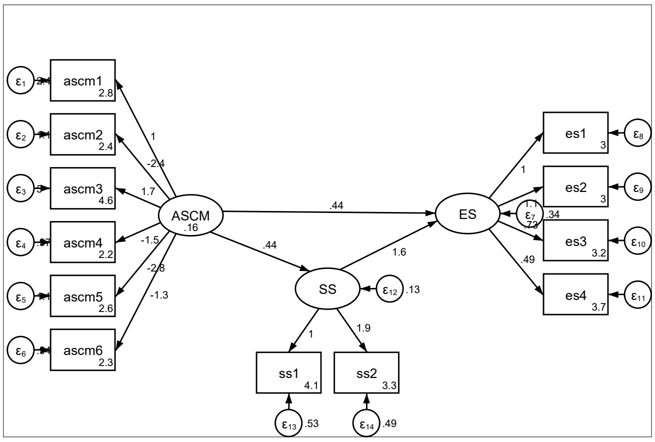

Fig. 7. Estimated Model 3

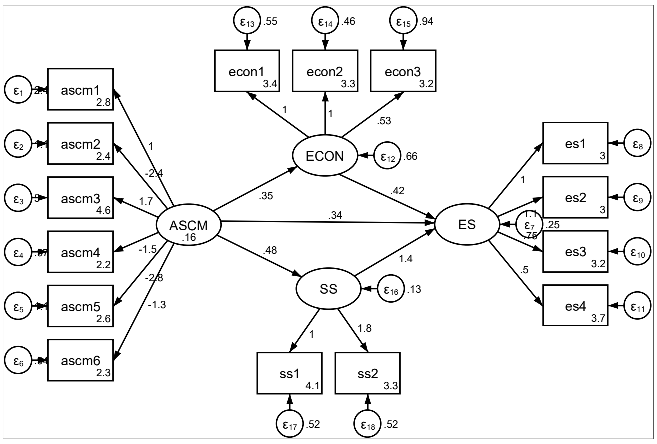

Fig. 8. Estimated Model 4

The SS also involves education and training to farmers and other stakeholders of ASCM, which would provide the basic knowledge about sustainable practices in the ASCM. The SS ensures the health and safety parameters in labor, which could help the labor avoid any mishandling of chemical fertilizers, pesticides, and other pollution-oriented substances. The SS improves the confidence of all stakeholders in each other and promotes cooperation among them to implement and support sustainable practices in the whole ASCM. Moreover, the SS can increase communities' inputs and innovations to adopt the local knowledge to promote the ES. In addition, social pressure motivates a higher level of compliance with environmental regulations and standards, which would improve the ES in ASCM. Thus, social sustainability helped the local agricultural sector to involve the community in more equitable resource distribution and fundamental knowledge to promote environmentally sustainable practices in ASCM in the Alkharj region. Table 5 and Fig. 8 show the results of estimated model 4, which carry the combined moderating effects of economic and social sustainability in the nexus between the ASCM and the ES. The estimated values of diagnostic tests are within critical bounds of the estimated model 4, which corroborates that model 4 is well-fitted. The results of model 4 corroborate that ASCM improves the both economic and social sustainability of the agriculture sector in Alkharj. In turn, economic and social sustainability improves the ES, which validates the hypotheses H6 and H7.

Table 5
Results of Estimated Model 4

Effect	Coefficient	SE	z-test	p-value
ES←ASCM	0.344	0.079	4.35	0.000
ECON←ASCM	0.353	0.099	3.57	0.000
ES←ECON	0.419	0.085	4.92	0.000
SS←ASCM	0.482	0.195	2.47	0.013
ES←SS	1.411	0.319	4.42	0.000
Diagnostic tests				
$\chi2$ /df	1.999			
CFI	0.963			
TLI	0.959			
RMSEA	0.075			
SRMR	0.093			

The results showed that economic and social sustainability played moderating roles in assisting the ASCM to improve the ES in the Alkharj governorate. Thus, both economic and social sustainability improve the capacity of labor, community, and agribusiness to put hand in hand to promote environmentally sustainable practices in the ASCM. The SS improves the support from labor and the local community to encourage sustainable practices with the help of education and fair treatment of the labor. Moreover, local communities put pressure on agribusiness to adopt compliance with environmental standards. In addition, economic sustainability provides the financial resources to agribusiness to make long-term investments in sustainable technologies and practices to ensure that agribusinesses maintain a good environmental performance in ASCM in Alkharj. Thus, together these economic and social sustainability provide a strong combination of economic and social support to implement environmentally sustainable practices in the agriculture sector in Alkharj.

5. Conclusion

The agriculture sector and its associated business can play a significant role in determining the environment. Thus, we investigate the effect of ASCM on the ES in the Alkharj governorate. Moreover, the moderating roles of social and economic sustainability in the nexus between ASCM and the ES are also analyzed. For this purpose, the primary data is collected from different stakeholders of ASCM in the Alkharj governorate. On the whole, 312 valid-filled responses were collected through a well-prepared questionnaire covering all items related to ACSM, the ES, the SS, and economic sustainability. ASCM has a direct positive effect on the ES in Alkharj, which reflects that the whole agriculture supply chain in Alkharj governorate is environmentally friendly. Moreover, the ASCM also improves economic and social sustainability. In turn, both economic and social sustainability improve the ES. Thus, both economic and social sustainability played their effective moderating roles in promoting the positive relationship between ASCM and the ES in Alkharj.

The SS improves the confidence of labor and community in agribusiness, which helps in adopting sustainable practices in the whole ASCM. The SS raises awareness among the labor and local communities about ES. Moreover, balanced labor practices ensuring health and safety in the workplace foster commitment among the workforce to be actively involved in environmentally friendly activities in the whole ASCM. In addition, education and training in SS practices provide basic knowledge about sustainable practices among the farmers and other stakeholders in ASCM, which helps in the adoption of ES practices. Moreover, social pressure from the community improved the compliance of environmental regulations by agribusiness, which helped in raising the ES. Side by side, economic sustainability provides the strength and financial capability for agribusiness to make long-term investments in sustainable technologies and practices. Thus, profits generated from economic sustainability are invested in eco-friendly resources and systems, irrigation methods, and REC sources, which help to improve the ES in the agriculture sector in Alkharj. So, economic sustainability increases the capacity of agribusinesses for long-term planning, market access, and revenue generation to support sustainable initiatives. Further, economic sustainability also fosters investment in recycling programs and waste management to reduce pollution in the whole ASCM. Thus, together social and economic sustainability helped in adopting sustainable practices in the whole ASCM to promote the ES in the agriculture sector in Alkharj governorate.

Based on the results, the present study recommends the agriculture sector to continue with sustainable practices in the whole ASCM to support the ES in this sector. Economic sustainability positively moderates the relationship between ASCM and the ES. Thus, the government of Alkharj governorate should support the farmers and other agribusiness to reduce their cost of operations and to raise their revenues. Moreover, the SS also positively moderates the relationship between ASCM and the ES. Thus, the government of Alkharj governorate should initiate the social program to promote education and health among the local communities and labor to further support the concept of ES in the whole ASCM. The present study could work on a limited region of the Alkharj governorate. The future study can increase the scope of the study by working on the whole Riyadh region to increase the generalization power of research for a bigger region in Saudi Arabia.

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