

FARMERS' AWARENESS OF DESERTIFICATION CAUSES IN AL-AFLAJ, SAUDI ARABIA

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ABSTRACT

Desertification leads to land degradation, yield reduction, biodiversity loss, poverty, hunger, and adverse effects on the natural environment. Saudi Arabia has a desert climate, with some parts of the country, particularly in the southwest, maintaining semi-arid conditions. The current study aimed to understand farmers' awareness about desertification causes in Saudi Arabia. This knowledge is essential for designing and implementing effective interventions that promote sustainable agricultural practices to combat desertification. Data were collected from farmers in the Al-Aflaj governorate in Saudi Arabia, using a simple random sampling technique with the help of a pre-tested paper-based questionnaire. The findings showed that the majority of the farmers were highly aware of the causes of desertification. Farmers' age, education level, residence, and access to agricultural extension information all had a significant impact on their awareness of the causes of desertification. The study suggests that extension education programs, with the active participation of the ecology department, should be implemented to raise farmer awareness. Furthermore, the government must facilitate the adoption of sustainable agricultural practices and innovative measures to combat desertification.

Keywords: awareness, desertification, climate change.

INTRODUCTION

Desertification is an environmental problem in arid and semi-arid regions worldwide that has a negative impact on environmental sustainability. It is primarily driven by natural forces like wind erosion, human activities, urbanization, and food scarcity (Amin and Seif, 2019). Desertification is aggravated by soil salinity, vegetation cover removal, sand encroachment, urbanization, and eolian processes, all of which have a negative impact on the environment and socioeconomic development (Aldakheel, 2011; Allbed *et al.*, 2014; Alqarni *et al.*, 2018; Almadini and Hassaballa, 2019). Furthermore, climate change, land mismanagement, extreme grazing, and deforestation accelerate desertification.

Desertification can be mitigated through the adoption of sustainable practices such as high-carbon input techniques, the use of modern crop varieties, crop rotation, cover cropping, perennial cropping systems, integrated production approaches, crop

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diversification, and agricultural biotechnology. Additional measures include balanced fertilizer application, precision nutrient management, reduced tillage intensity, and innovative water management strategies for both the drainage of waterlogged mineral soils and the irrigation of crops in arid and semi-arid regions (Smith *et al.*, 2020).

The global climate is experiencing several transformations, including rising temperatures, increased levels of carbon emissions, instabilities in ultraviolet radiation, and unpredictable changes in rainfall patterns caused by extreme weather events (Raza *et al.*, 2024). Saudi Arabia is highly vulnerable to climate change due to its arid climate and limited precipitation. Climate change poses a major challenge to sustainable agriculture and exacerbates food insecurity in the country. Increasing climate variability further intensifies drought and desertification, leading to reduced crop yields and heightened risks of food insecurity (Alotaibi *et al.*, 2023; Hasan *et al.*, 2023). High temperatures could increase water loss through evapotranspiration by 10.3–27.4 % and alter the rainfall pattern for the northern regions (Ullah *et al.*, 2024). Saudi Arabia is the largest country in the Middle East, with a total area of approximately 2.25 million km². It encompasses various natural features, including mountains, plateaus, plains, valleys, and sand dunes. The country is predominantly characterized by an arid to semi-arid climate, with over 90 % of its territory classified as desert land. Furthermore, approximately 7 % of its land is highly vulnerable to desertification, posing significant threats to ecosystems and agricultural productivity, particularly by limiting plant growth (Abahussain *et al.*, 2002). In 2013, Saudi Arabia used more than 4.252 million ha of agricultural land, with 694 549 ha designated as invested agricultural lands and 3.558 million ha as non-invested lands. However, by 2018, the total cultivated area had decreased to 994 815 ha (MEWA, 2018).

The ongoing demand for water resources has accelerated desertification in Saudi Arabia, where the lack of perennial surface water requires dependency on groundwater for irrigation (Abahussain *et al.*, 2002). Several villages are already experiencing desertification, while many others remain at high risk. The Al-Aflaj governorate, bordered by the Al Dahna and Rub' al-Khali deserts, is particularly vulnerable to desertification (Salih *et al.*, 2021) due to below-average rainfall in recent years. To address these challenges, soil scientists recommend strategies such as diversifying agricultural fertilizers and implementing careful irrigation management, which may help mitigate the adverse effects of desertification in the area (Al-Dosary, 2022).

Agricultural extensionists, who collaborate with farming societies at the local level, suggest that the dissemination of eco-friendly technologies in climate-prone regions of Saudi Arabia could minimize climate-related effects on agriculture (Alotaibi *et al.*, 2023). Innovative information dissemination to farmers is one of the primary goals of agricultural advisory services (Gao *et al.*, 2021). In many developing countries, the agricultural extension department is increasing awareness and adoption of sustainable agricultural practices that could mitigate climate effects and desert conditions (Ashraf *et al.*, 2017; Raza *et al.*, 2020).

Mitigation and control of desertification depend on key strategies, including sustainable agricultural and grazing practices, enhanced water management, and forest cultivation (Zhang and Huisingsh, 2018). However, the effective implementation of these strategies requires evaluating farmer awareness of desertification causes, as low levels of awareness can hinder adoption and reduce their overall effectiveness. Although numerous studies have explored the biophysical aspects of desertification, there remains a notable gap in social research focusing on farmers' awareness of desertification causes.

The present study aims to analyze farmers' awareness of desertification causes in Al-Aflaj, Saudi Arabia. This could help with the development of policy and awareness programs that encourage the use of more sustainable practices to combat desertification. Awareness was assessed in relation to their socioeconomic characteristics, leading to the formulation of the following hypotheses: H1: Age, education, residence, occupation, farming experience, land tenure, and farm size influence farmers' awareness of desertification causes; H2: Information received from the agricultural extension department regarding desertification affects farmers' awareness.

MATERIALS AND METHODS

Description of the study area

The Al-Aflaj governorate is located in the southern part of the Najd Plateau, approximately 312 km from Riyadh. It is bounded to the west by the Tuwaiq Escarpment, the Al Dahna Desert to the east, Al-Kharj Province and Wadi Birk to the north, and Wadi Al Dawasir Province and the Al-Rub Al-Khali Desert to the south. The terrain transitions from plains in the east and forms plateaus along the western flank, adjacent to the Tuwaiq Escarpment. The region has natural water resources, including aquifers and deep groundwater in Al Minjur, Al Biyadh, and Al Wasia (Al-Dosary, 2022).

The land is arable and classified as appropriate for agricultural investments, with the majority of the population involved in farming. The area is ideal for seasonal grass, with approximately 30 % of the total land under cultivation. Major crops grown include wheat, barley, forage crops, vegetables, and a variety of seasonal fruits. Irrigation practices in Al-Aflaj primarily rely on drip systems, surface irrigation, and center-pivot irrigation (MEWA, 2018).

Research design and instrument development

The Al-Aflaj governorate was specifically selected due to its extensive agriculture (Al-Dosary, 2022). A simple random sampling technique was used to select 350 farmers from this region. Data was collected using a paper-based, structured questionnaire distributed to farmers in their native Arabic language. They were informed of the reason for the study and assured that the collected data would be used solely for

academic and research purposes. Out of the 350 farmers, 186 (82 %) returned the complete questionnaires, which were used for the final data analysis.

The questionnaire was reviewed and validated by a panel of researchers from the Department of Agricultural Extension and Rural Sociology at King Saud University, after which a pilot study was conducted to test the reliability of the Likert scale. Data were collected from 30 farmers, and Cronbach's alpha coefficient (α) was calculated to assess the internal consistency and reliability of the questionnaire (Bonett and Wright, 2015). A Cronbach's alpha value of 0.7 or higher is generally considered acceptable for further research (Cronbach, 1951; Schmitt, 1996). In this study, the coefficient was estimated at 0.79, indicating satisfactory reliability. Following these procedures, the field survey was carried out.

The questionnaire included three sections. The first focused on the socioeconomic characteristics of the respondents, including age, education, residence, occupation, farming experience, land tenure, farm size, and access to extension information on desertification, all measured on a nominal scale (0 = no; 1 = yes). Respondents' age was classified as young (18–42 years) or older (>42 years); education level as low (school) or high (college or university); farming experience as low (3–24 years) or high (>24 years); and farm size as small-scale (ownership of 2–240 ha) or large-scale (>240 ha).

The second section examined the irrigation systems used by farmers, distinguishing between drip irrigation, surface irrigation, and sprinkler systems, each measured on a nominal scale (0 = no; 1 = yes). The third section assessed farmers' awareness of the causes of desertification through a five-points Likert scale (1 = not aware at all; 2 = slightly aware; 3 = somewhat aware; 4 = moderately aware; 5 = extremely aware).

Data analysis

Data were analyzed using descriptive and inferential statistics. Socioeconomic characteristics were summarized with frequencies and percentages, while farmers' awareness of desertification causes was assessed using frequencies, means, and standard deviations. To determine differences in the farmers' awareness due to their personal demographics, parametric statistics were used. A principal component analysis (PCA) was used to reduce the dimensionality of large data sets. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) was performed to measure the suitability of the survey response data. For the nominal variables with two categories (age, education level, farming experience, land tenure, residence, farm size, and source of information), the independent *t*-test was used. The Statistical Package for Social Sciences (SPSS version 28.0, IBM SPSS Statistics) was used for running the data analysis.

RESULTS AND DISCUSSION

Regarding age, the findings revealed that most of the respondents (52.2 %) were older, while 48 % were classified as young (18–42 years). In terms of education, the majority

(64.5 %) had a high level of education, holding a college degree or higher, whereas 36 % had only school-level education. Regarding residence, most of the respondents (59.1 %) lived in urban areas, while 41 % lived in rural areas. Most respondents (74 %) had limited farming experience, while 26 % had a high level of experience. Data showed that 83.3 % of respondents owned their agricultural land, whereas 16.7 % operated farms in partnership. Farm size distribution showed that 96 % managed small landholdings, while only 4.3 % cultivated large areas of 240 ha or more. Finally, in terms of access to information on desertification, the majority of respondents (83.3 %) did not seek advice from the Agricultural Extension Department, while only 16.7 % did on a regular basis (Table 1).

More than 70 % of the farmers used drip irrigation (Table 2). On the other hand, three-fifths used sprinkler irrigation, pivot sprinklers, or surface/flood irrigation systems on their farms.

Table 1. Frequency and percentage distribution of respondents' socioeconomic characteristics in Al-Aflaj, Saudi Arabia (n = 186).

Variables	Frequency (n)	Percentage
Age		
Young (18–42 years)	89	47.8
Older (>42 years)	97	52.2
Education		
Low (school degree)	66	35.5
High (college or university degree)	120	64.5
Residence		
Rural	76	40.9
Urban	110	59.1
Occupation		
Part time farming	155	83.3
Full time farming	31	16.7
Farming experience		
Low experience (3–24 years)	138	74.2
High experience (>24 years)	48	25.8
Land tenure		
Partnership	31	16.7
Ownership	155	83.3
Farm size		
Small scale farming (2–240 ha)	178	95.7
Large scale farming (>240 ha)	8	4.3
Information from the Agricultural Extension Department on desertification		
Does not receive information	155	83.3
Receives information	31	16.7

Table 2. Types and prevalence of irrigation systems used for agricultural purposes in Al-Aflaj, Saudi Arabia.

Irrigation systems	Yes (%)	No (%)
Drip irrigation	71	29
Sprinkler irrigation	17.2	82.8
Pivot sprinkler irrigation	22	78
Surface or flood irrigation	22.6	77.4

Farmers had relatively high awareness of the causes of desertification (Table 3). More than three-fifths extremely recognized high temperatures as a major driver, while half linked desertification to population growth, and 58.6 % identified creeping sand dunes as an important cause. In addition, over two-fifths showed strong awareness of other drivers, including land degradation (45.7 %), water depletion (48.7 %), lack of trees (48.9 %), the spread of unwanted weeds (41.4 %), bare sand accumulation (43.5 %), and tree cutting for firewood (40.9 %).

Table 3. Farmer awareness of the causes of desertification in Al-Aflaj, Saudi Arabia, expressed as percentages, mean scores, and standard deviations (SD) (n = 186).

Items	Not aware at all (%)	Slightly aware (%)	Somewhat aware (%)	Moderately aware (%)	Extremely aware (%)	Mean	SD
Creeping sand dunes	2.7	2.7	16.7	19.4	58.6	4.28	1.01
High temperatures	2.7	5.4	12.4	17.2	62.4	4.28	1.01
Lack of trees	4.8	10.8	15.1	20.4	48.9	3.98	1.23
Land degradation	5.4	9.1	16.1	23.7	45.7	3.95	1.21
Bare sand accumulation	5.9	10.8	16.7	23.1	43.5	3.88	1.24
Water depletion	10.2	8.1	16.7	16.7	48.4	3.85	1.37
Spread of unwanted weeds	5.4	10.8	18.3	24.2	41.4	3.85	1.22
Population growth	15.6	8.1	10.2	16.1	50.0	3.77	1.51
Increased number of animals for grazing	5.4	12.4	19.9	26.3	36.0	3.75	1.21
Increased irrigation	7.0	10.8	23.1	19.9	39.2	3.74	1.27
Soil exposure to gusts of wind	6.5	7.0	26.9	25.8	33.9	3.74	1.18
Low agricultural productivity	8.1	10.8	21.0	22.0	38.2	3.72	1.29
Increased water withdrawal	12.4	10.8	16.7	20.4	39.8	3.65	1.41
Vegetation cover removal	15.1	11.3	11.3	18.8	43.5	3.65	1.49
Tree cutting for firewood	15.1	9.7	14.5	19.9	40.9	3.62	1.47
Soil salinization	11.8	12.9	17.7	24.2	33.3	3.54	1.37
Lack of modern irrigation systems	10.8	13.4	21.5	25.3	29.0	3.48	1.32
Lack of rainfall	11.3	14.5	26.3	16.7	31.2	3.42	1.35
Soil erosion	10.2	11.8	32.8	19.4	25.8	3.39	1.26
Overgrazing	11.3	13.4	25.3	26.3	23.7	3.38	1.29
Presence of canyons and valleys	11.3	18.3	23.1	17.2	30.1	3.37	1.37
Overuse of fertilizers	9.1	19.9	28.0	22.0	21.0	3.26	1.25

Other contributing factors were also acknowledged, though to a slightly lesser extent (Table 3). More than 30 % of the farmers were extremely aware that low agricultural productivity, soil salinization, the presence of canyons and valleys, soil exposure to frequent gusts of wind, lack of rainfall, increased irrigation, increased number of animals for grazing, and increased water withdrawal can lead to desertification. In addition, less than 30 % of farmers were extremely aware that soil erosion, overgrazing, overuse of fertilizers, and lack of modern irrigation systems caused desertification. Less than 16 and 20 % were not aware at all and slightly aware about the causes of desertification, respectively. Less than 33 and 37 % were somewhat and moderately aware, respectively.

Results revealed that half of the farmers were extremely aware of the causes of desertification (Figure 1), while about two-fifths demonstrated moderate awareness. Fewer than 7 % reported having no awareness. Overall, the findings show that most respondents possessed a high level of awareness of the causes of desertification.

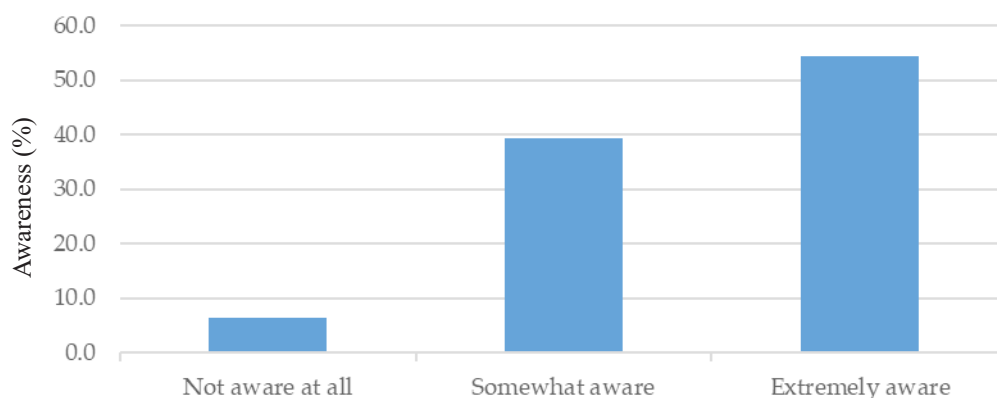


Figure 1. Overall farmer awareness levels of desertification in Al-Aflaj, Saudi Arabia.

These findings are consistent with Fekadu and Kumssa (2020), who reported that most farmers were highly aware of the causes of land degradation and desertification, citing factors such as population growth, over-tilling, soil erosion, rocky topography, poor agricultural practices, and poverty. Similarly, Owusu *et al.* (2024) found a high level of awareness among farmers in Ghana, which was attributed to agricultural extension programs, field demonstrations, and seminars that enhanced farmers' knowledge. In contrast, Yassin (2019) reported low awareness of desertification among Sudanese farmers, demonstrating the importance of awareness campaigns and technology transfer through active engagement of relevant institutions.

Higher awareness of the causes of desertification among farmers in the study area may be attributed to large-scale national and regional campaigns. The government of Saudi Arabia has actively communicated the severity of desertification as an environmental challenge for agriculture and land management. Several initiatives, including the

Saudi Green Initiative, the Green Riyadh Project, and the Middle East Green Initiative, have been launched to address this issue (UNDP, 2024). Additionally, the Ministry of Environment, Water, and Agriculture (MEWA) and the United Nations Convention to Combat Desertification (UNCCD) have organized workshops involving multiple stakeholders and experts to raise awareness (UNDP, 2024).

The Saudi Green Initiative has seen rapid progress at the community level, with villagers planting an estimated 250 000 trees and one million shrubs in desert areas. Furthermore, the Food and Agriculture Organization (FAO) and Saudi Arabia’s National Center for Vegetation Development and Combating Desertification (NCVC) have provided technical guidance and remote training courses. The active participation of farming communities in these programs has likely played a crucial role in strengthening their awareness of the causes of desertification (UNDP, 2024; UNSDG, 2024).

To better understand farmers’ awareness of desertification, specific factors were grouped using principal component analysis (PCA). Three factors were extracted, accounting for 60.8 % of the total variance (Table 4). Factor 1 includes human and

Table 4. Principal component analysis of farmers’ awareness of desertification in Al-Aflaj, Saudi Arabia.

Items	Factor 1	Factor 2	Factor 3
	Explained variance		
	41.82 %	12.56 %	6.42 %
Land degradation		0.783	
Vegetation degradation		0.752	
Water depletion		0.819	
Low agricultural productivity		0.802	
Soil salinization		0.720	
Lack of trees		0.745	
Spread of unwanted weeds		0.760	
Bare sand accumulation		0.760	
Creeping sand dunes			0.755
High temperature			0.804
Soil erosion by torrential water	0.642		
Population growth	0.739		
Tree cutting for firewood	0.752		
Vegetation cover removal	0.761		
Overgrazing	0.631		
Overuse of fertilizers	0.616		
Increased irrigation	0.705		
Increased number of animals for grazing	0.780		
Increased water withdrawal from wells	0.831		
Lack of modern irrigation systems	0.797		

Factors explain 60.8 % of the variance. Kaiser-Meyer-Olkin measure of sampling adequacy (0.889), $p < 0.0001$).

agricultural pressures (10 items), which reflect anthropogenic drivers of desertification. Factor 2 (eight items) captures the ecological consequences of land misuse, while factor 3 (two items) represents natural and climate-related pressures.

Farmers' awareness according to their socioeconomic characteristics

Significant differences were observed according to age ($t = -2.64, p < 0.001$), education level ($t = -5.23, p < 0.001$), residence ($t = 2.37, p = 0.01$), and access to extension information ($t = -2.23, p = 0.02$). To assess the magnitude of these differences, effect sizes were calculated using Cohen's d (Table 5) (Lakens, 2013; Goulet-Pelletier and Cousineau, 2018).

Older farmers demonstrated higher awareness of desertification than younger farmers, although the mean difference indicated only a small effect ($d = 0.38$) (Table 5). It has been observed that the older the farmers are, the more agricultural experience they have and the better their ability to gain technical and meteorological knowledge

Table 5. Independent samples t -test results for differences in farmers' awareness of desertification by socioeconomic characteristics in Al-Aflaj, Saudi Arabia.

Variables	Mean	Standard deviation	t	p -value
Age				
Young (n = 89)	32.25	7.56	-2.64	<0.001 $d = 0.38$
Old (n = 97)	35.17	7.46		
Education				
Low education (n = 66)	30.08	8.50	-5.23	<0.001 $d = 0.76$
High education (n = 120)	35.80	6.27		
Residence				
Rural (n = 76)	35.35	6.72	2.37	0.01 $d = 0.36$
Urban (n = 110)	32.68	8.05		
Farming experience				
Low experience (n = 138)	33.45	7.62	-0.98	0.32
High experience (n = 48)	34.70	7.67		
Occupation				
Full time farming (n = 155)	33.88	7.78	0.42	0.67
Part time farming (n = 31)	33.24	6.95		
Land tenure				
Partnership (n = 31)	32.27	6.85	-1.20	0.23
Ownership (n = 155)	34.07	7.76		
Farm size				
Small scale farming (n = 178)	33.66	7.68	-0.96	0.33
Large scale farming (n = 8)	36.31	6.11		
Information from extension about desertification				
No (n = 155)	33.22	7.76	-2.23	0.02 $d = 0.46$
Yes (n = 31)	36.54	6.37		

of the causes of desertification. Older farmers seemed more inclined to adopt strategic measures against desertification (Tai *et al.*, 2020). Wei and Wang (2017) found that older farmers are usually responsible for their livelihood and have great ability to sense environmental risks such as climate change and desertification (Alotaibi *et al.*, 2020, 2024).

Highly educated farmers demonstrated significantly greater awareness of desertification than those with lower education (Table 5), with the difference in means reflecting a large effect ($d = 0.76$). This may be attributed to their greater access to diverse sources of information, such as scientific publications, magazines, and news articles, which facilitate continuous information updates (Geeson *et al.*, 2015). In addition, MEWA has distributed more than 230 000 specialized educational materials during various agricultural events, covering topics such as logging and desertification, modern irrigation systems, red palm weevil control, fertilization, and the conservation of coral reefs and mangrove ecosystems (MEWA, 2024). Such initiatives may help explain the higher awareness levels among highly educated farmers compared to their less educated counterparts.

Educated farmers are more likely to participate in training programs and workshops related to desertification. Previous studies have shown that they also access information through multiple channels, including newspapers and magazines, which further enhances their knowledge base (Geeson *et al.*, 2015; Mashi *et al.*, 2022). Furthermore, highly educated respondents to this study reported significant agricultural production losses due to desertification, recounting experiences with land degradation, climate change, and drought. They also appeared more proactive in adopting nature-based solutions, such as tree planting and vegetation restoration, to rehabilitate degraded land.

Farmers residing in rural areas demonstrated relatively higher awareness of desertification compared to those living in urban areas (Table 5). Although the mean difference represented only a small effect ($d = 0.36$), this finding is understandable. Farmers who spend more time in rural environments often develop a deeper understanding of the interactions between humans and nature, the value of natural ecosystems, and the importance of environmental protection. Since most rural populations are directly engaged in agriculture, desertification-related projects and initiatives often target these communities. Rural communities also tend to participate more actively in discussions with development agencies and in training programs designed to enhance environmental knowledge (Chao *et al.*, 2019).

Several initiatives illustrate the importance of community participation in combating desertification. For instance, the Ghana Environmental Management Project (GEMP) particularly aimed to strengthen institutions and empower rural communities to address desertification (Fuseini, 2014). In Saudi Arabia, the NCV, in collaboration with FAO, organized a training course on climate change and desertification in 2022. These programs encouraged participants to discuss local conditions and challenges, thereby improving awareness and adaptive capacity. Farmers in the study area

may benefit from such opportunities by engaging in workshops and community discussions, which likely contributed to their relatively higher awareness levels (UN, 2022).

Farmers who received information about desertification from the extension department demonstrated higher awareness than those who did not (Table 5), with the difference in means reflecting a small effect ($d = 0.46$). Extension activities serve as important channels for technology transfer and the dissemination of innovative practices that enhance farmers' awareness and knowledge of environmental challenges (Alzahrani *et al.*, 2023; Muddassir and Alotaibi, 2023).

Between 2015 and 2016, MEWA organized a wide range of activities to raise awareness of desertification and promote sustainable agronomic practices. These included 99 pilot fields, 23 public events, an agricultural extension forum, 175 extension lectures, 159 tours and field visits, and 69 extension meetings (MEWA, 2024). Furthermore, the Center for Desert Agriculture (CDA) at King Abdullah University of Science and Technology (KAUST), in collaboration with the NCVC, established the KAUST-NCVC Experiment Station and Ecological Observatory (KNESEO), which serves as a hub for agricultural and environmental research by providing experimental stations, infrastructure, technical expertise, and extension services. By granting access to advanced research and training, the center strengthens awareness of desertification, ecological conservation, water management, and sustainable food production (CDA, 2024).

The Saudi Green Initiative and KNESEO may encourage agricultural extension departments to provide more targeted training for farmers on the causes of desertification and eco-friendly practices. Active participation in extension activities, such as lectures, tours, field visits, and meetings, has the potential to significantly improve farmers' awareness of desertification drivers (Dabiah *et al.*, 2023). Similar efforts have been observed in other regions. For example, the European Parliament has promoted awareness of desertification and sustainable agriculture through awareness-raising campaigns (Rossi, 2020).

The present study contributes to the existing literature in several ways. First, it provides empirical insights into farmers' awareness of the causes of desertification in the study area, offering a deeper understanding of how awareness levels differ across socio-economic characteristics. Second, the findings highlight the importance of establishing mechanisms through which agricultural departments and environmental agencies can design effective educational programs, training initiatives, and informational materials to promote sustainable agricultural practices as a means against desertification.

CONCLUSIONS

This study found that the majority of farmers in Al-Aflaj, Saudi Arabia, were aware of the causes of desertification. Farmers who belonged to older age groups, had higher education, resided in rural areas, and received information from agricultural

extension departments had a better understanding of the causes of desertification. The findings may have various policy implications. Agricultural extension services play an important role in raising awareness and promoting sustainable practices, emphasizing the need for stronger collaboration between government agencies and environmental institutions. Awareness can be further strengthened through targeted seminars, workshops, and training programs, as well as mass media campaigns, such as radio, television, and local newspapers, that communicate both the risks of desertification and the benefits of eco-friendly agricultural practices.

The study has some limitations. Since the sample was restricted to the Al-Aflaj governorate, the findings may not be representative of all farming regions in Saudi Arabia. Future research should be done in order to measure awareness and the adoption of sustainable practices in other areas, particularly those most vulnerable to desertification in Saudi Arabia, to provide broader evidence for national strategies aimed at environmental sustainability.

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