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Investigation of socio-cultural drivers of desertification and land degradation in the Sistan region, Southeast of Iran

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Abstract

Desertification typically results from a combination of climate change and anthropogenic effects. Changes in global and regional precipitation patterns can be major drivers of desertification and have historically caused the expansion and contraction of Earth's major deserts. Desertification is also considered to be a cause and a consequence of socio-economic and political instability in developing nations. This paper investigates the socio-cultural drivers of land degradation and desertification in Sistan region in the southeast of Iran. some of the recurrent anthropogenic disturbances and societal drivers that specifically contribute to Sistan's desertification were considered. For this purpose, we followed three steps in our survey. We used questionnaires for each step of surveying land degradation drivers including: i) collecting overall factors, ii) selecting candidate factors from among six categories, and iii) identification, introducing and ranking factors priority based on their importance in desertification. The process was completed in collaboration with managers, experts, and administrators in the field of combating desertification at the provincial level. Based on correlation statistics and multivariate analyses, social participation deficit exhibited the highest share (20.41%), followed by cultural issues (19.32%), migration and land abandonment (17.36%), knowledge weakness (16.76%), social values (13.12%) and land ownership (13.008 %). Also, more than 18 factors out of 38 were found to be significant in affecting land degradation and desertification in the Sistan region. Among them, the most important were lack of a system for using local wetland's goods and services, farrow land cultivation, traditional farming, lack of confidence in experts, monoculture of cereals, and ignorance of indigenous knowledge. Results contribute to the development of a deeper conception among decision makers, experts and regional administrators and appropriate tools for assessing the effectiveness of land management practices for combating land degradation and desertification.

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Introduction

Increasing ecosystem change on a global scale has been recognized as one of the major environmental challenges of the past century (Millennium Ecosystem Assessment, 2005). Severe land degradation processes, possibly leading to irreversible phenomena of desertification, are impacting developed regions and emerging economies where climate aridity, poor soil quality, and restricted vegetation cover are constraints to agricultural production, natural vegetation, and human well-being (Mouat and Hutchinson, 1996; Middleton and Thomas, 1997; Conacher and Sala, 1998; Geist, 2005) raising increasing concern at the continental and country level (Steffen, 2004). Desertification typically results from the compound effect of climate change and land use. Changes in the global and regional patterns of precipitation can be major drivers of desertification and have historically led to the expansion and contraction of major deserts on Earth (D'Odorico et al, 2013). Desertification, however, cannot be convincingly explained as a phenomenon based on changes in biophysical factors only, since it rarely occurs without human activities influenced by global, regional, and local socioeconomic drivers (Safriel and Adeel, 2008). Authors who include natural processes among causes of land degradation (LD) essentially agree on the basic division of causes into natural (biophysical) and human-induced causes (Nachtergaele et al., 2011; Nkonya et al., 2011). Land vulnerability to desertification depends on the interplay between natural (e.g. climate aridity, drought, soil degradation, poor vegetation cover) and human-derived factors (e.g. overgrazing, forest fires, landscape fragmentation, soil pollution, urbanization). The role of anthropogenic factors as key drivers of LD has been increasingly studied depending on the natural resource endowments (Wilson and Juntti, 2005). Underdevelopment, rural poverty and increasing human pressure in ecologically fragile areas have been hypothesized to be decisive to exacerbate the environmental conditions possibly leading to desertification (Blaikie and Brookfield, 2000; Boyce, 1994; Barbier, 2000; Reynolds and Stafford-Smith, 2002; Boardman et al., 2003; Iosifides and Politidis, 2005; Romm, 2011). These processes are largely driven by changes in the socioeconomic context, and strongly impact the way the land is being used (Antrop, 2005). Land degradation has been considered a typical phenomenon associated with agro-pastoral landscapes that are undergoing late economic development (Basso et al., 2000; Marathianou et al., 2000; Helldén and Tottrup, 2008; Imeson, 2012). Sometimes this process is interpreted as a downward spiral fueled by a persistent socioeconomic imbalance between vulnerable, disadvantaged areas and the neighboring, competitive regions (Salvati and Zitti, 2008). As desertification is both a cause and a consequence of socio-economic and political instability in developing countries, the mitigation of desertification is necessary [MEA, 2005].

However, despite its impacts on over one-third of the world population, the human dimensions of desertification remain poorly understood (Ibrahim, 1993; Reynolds and Stafford Smith, 2002). To identify the role of the anthropogenic factors involved in land degradation processes is crucial and has policy implications because of the increasing impact of both external drivers (e.g. climate changes) and internal forces (e.g. social, cultural, and political changes, evolution of the economic structure, global financial crisis) on natural resources and landscapes (Sivakumar and N'diangui, 2007). Although recent studies have tried to answer this complex issue (Portnov and Safriel, 2004; Danfeng et al., 2006; Wang et al., 2006; Wessels, 2007; Abu Hammad and Tumeizi, 2012), further investigation on the local scale is needed (Salvati, 2014). The main anthropogenic causes are associated with poor land management resulting in overgrazing or unsustainable agricultural practices beyond the limits allowed by these vulnerable environments. Some of these practices enhance soil erosion or salt accumulation in the shallow soil. Land mismanagement is often caused by lack of knowledge, greed, changes in the global economy, and remoteness/ marginalization (e.g., Reynolds and Stafford Smith, 2000; Reynolds and Stafford Smith, 2002; MEA, 2005; Reynolds et al, 2007). Several causes may seem to be natural, but are in fact entirely, partially, or indirectly affected by humans and their activities (e.g. air quality, climate characteristics, soil vulnerability, water shortage, vegetation characteristics) (Sklenicka, 2016). In terms of the distribution of individual LD types, water and wind erosion together with the loss of biodiversity most frequently occur in less populated areas, while in agricultural areas the dominated types are water shortages, soil depletion, and soil pollution (Nachtergaele et al., 2011)

The adoption of desertification control measures requires the identification and monitoring of early warning signs or indicators of desertification. Commonly used indicators (Baartman, 2007; Vogt et al., 2011) span biophysical (e.g., land cover change, biodiversity loss, soil fertility), economic (e.g., declining crop yields, reduced fodder production, household income, and market efficiency), social (e.g., increased rural-urban migration, population structure changes, declining social solidarity, deteriorating health, rising unemployment rates), and political factors (e.g., weakening state power, immigration-related conflicts) (Ibrahim, 1993). Monitoring involves acquiring information through field surveys, existing records, and remote sensing (Baartman, 2007; Vogt et al., 2011).

While studies have been conducted to define the causes and consequences of land degradation, desertification, and land abandonment at the local scale (Corbelle-Rico et al., 2012; Helming et al., 2011; Strijker, 2005; Alibecov, 2008), until recently, indicators used for land degradation and desertification assessments were primarily based on biological and physical factors, with humans typically viewed only as contributors to the causes of desertification (Ibrahim, 1993). There is no definitive list of land degradation types or causes, and it is likely that one will never exist (Sklenicka, 2016).

Also, he causes of LD have not been comprehensively deliberated in terms of their typology, interrelationships, or possible effects. Not even the terminology is unified, as in addition to the frequently used term “cause” (e.g., Stocking and Murnaghan, 2001; Nachtergaele et al., 2011; Nkonya et al., 2011), some authors (e.g., Barbier, 1997) have used the term “determinant”, and others (e.g., Meadows and Hoffman, 2002) have used “factor.” Tefera et al. (2002) used the two terms cause and factor, while Nachtergaele et al. (2011) used both cause and driver, without detailing any differences in their interpretation. It is necessary, however, to acknowledge one essential difference between the term cause and the terms factor, determinant, and driver. The term “cause” carries with it a negative connotation of the agency, while “factors”, “determinants”, and “drivers” simply indicate the occurrence of the phenomenon, without raising the issue of an agent responsible for the negative effects of what has happened (Sklenicka, 2016). A comprehensive approach aimed at identifying regional-scale drivers using indicators deserves further investigation. The necessity of offering detailed indicators is a research priority claimed by United Nations Convention to Combat Desertification (UNCCD) (COP, 2009). Although the indicators selected in this study cannot be considered as an exhaustive description of the socio-cultural context, they provide a broad qualification of the social characteristics at the local scale. The study sites are in areas affected or sensitive to land degradation and desertification by a variety of processes and causes such as drought, salinity, soil erosion, and overgrazing. As a result of natural drought and human actions, Hamoun lakes in Iran have dried up, and sandstorms buried dozens of villages and destroyed farmland (Weier 2003). Since every social system has two social sub-dimensions (socio-economic and socio-cultural) (Barrow, 2000), the present study investigates the proximate and underlying (salvatti, 2014) socio-cultural causes affecting land degradation and desertification.

Materials and methods

Study area

The Sistan region as a large and remote desert basin (30O50'N to 31O28'0"N and 61O15'0"E to 61O50'0"E), including Zabol, Zahak, Hamoun, Hirmand, and Nimrooz townships with overall 400,000 people is a topographic-low basin located in southeastern Iran close to the Iranian borders with Pakistan and Afghanistan. The northern edge of the Sistan region comprises the topographically low Hamoun basin, which is a depression that receives the discharge from the Helmand (Hirmand) river and its tributaries (Figure 1). Sistan has 60000 ha of forest, 500000 ha of poorly rangeland, and over 50000 ha of sand dunes most of which shift and damage the infrastructure and inhabitants.

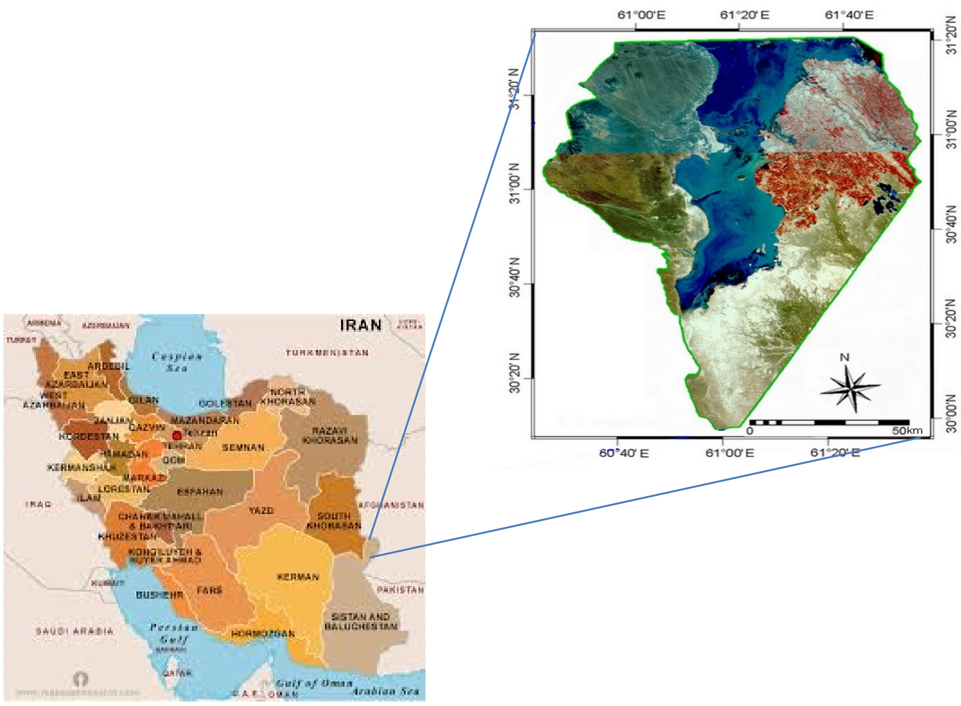

Figure 1. the situation of Sistan in Iran and satellite map of the Sistan region showing Hamoun lake

Climate condition

Sistan is an extremely arid region characterized by windstorms, extreme floods, and droughts. The climate is hyper-arid, with an annual average precipitation of approximately 55 mm, mostly occurring in winter (December to February), and evaporation exceeding 4000 mm per year (Moghaddamnia et al., 2009). The region's most significant meteorological phenomenon is the "Levar" northerly wind, commonly referred to as the "120-day wind," which causes frequent dust and sandstorms, especially between June and August. This makes Sistan one of the windiest deserts globally (Moghaddamnia et al., 2009; Rashki et al., 2012, 2013a,b). Levar results from the expansion of the Indian thermal low over Iran and Afghanistan, while its variations are influenced by changes in mean sea-level pressure between the Caspian Sea and the Hindu Kush mountains (Kaskaoutis et al., 2015b, 2016). These winds contribute to frequent and severe dust storms often enriched with saline salts ($NaCl$, Na_2SO_4, $CaCl_2$, $MgCl_2$) (Dahmardeh Behrooz et al., 2017). These storms impact soil and water salinity, health issues, and damage infrastructure and communities, including Zahedan, located 200 km south of Sistan (Rashki et al., 2012).

Water resources

Ninety-five percent of the Helmand Basin is located in Afghanistan. However, due to the lack of other economically viable groundwater sources, it serves as the primary water resource for major cities in Sistan and Baluchestan Province, as well as for Sistan's farmlands and wetlands (van Beek & Meijer, 2006). The Iranian part of the basin is arid and rocky, generating runoff only during rare, significant rainfall events. The Hamoun lakes complex (Hamoun-e-Puzak, Hamoun-e-Sabori, Hamoun-e-Hirmand, and Baringak) forms the largest freshwater ecosystem on the Iranian plateau and was one of the first wetlands recognized by the Ramsar Convention (Moghaddamnia et al., 2009). Water depth in the Hamoun lakes rarely exceeds 3 meters, and their size fluctuates both seasonally and annually based on water availability. During summer, the lakes often dry up completely (Rashki et al., 2013a; Sharifikia, 2013). Maximum lake expansion occurs in late spring following snowmelt in the mountains. In exceptionally high runoff years, the Hamoun lakes combine into one large body of water, approximately 160 km long, 8–25 km wide, with a surface area of about 5,700 km^2 and a volume of 13,000 million m^3 (Sharifikia, 2013). Decreased surface water flow in the Helmand River system has contributed to increased desertification (UN Water & FAO, 2007). However, due to significant variation in mountain runoff and precipitation, the Hamoun lakes completely dried up at least three times during the 20th century (Whitney, 2006). The resulting silt layer of saline sediment in the dry lakebed is easily eroded by wind, making the basin one of the most active dust sources in Southwest Asia (Hoseini et al., 2010; Ekhtesasi & Gohari, 2013; Cao et al., 2015).

Geology and Soil

Geologically, the Sistan plain consists primarily of Quaternary lacustrine silt and clay materials, as well as Holocene and Neogene fluvial sand, aeolian sand, silt, and clay carried into the basin by rivers (British Geological Survey). The area is a flat plain with elevations ranging from 479 to 515 meters above sea level and slopes of less than 2%. Land cover includes farmland, saline land, abandoned land, and sand dunes. The region's common soils include Entisols, Inceptisols, and Aridisols (Pahlavan-rad & Akbarimoghaddam, 2018), which are deltaic soils of the Hirmand River. The landscape is dominated by aeolian erosion and deposition landforms (Whitney, 2006). Sistan's average soil texture is sandy loam, but soil properties vary significantly with distance from rivers and channels. Soils farther from water sources tend to have finer textures, higher salinity, alkalinity, and waterlogging in low-lying areas, limiting plant growth (Pahlavan-rad & Akbarimoghaddam, 2018). Mirakzehi et al. (2018) attribute soil formation in the Sistan plain to fluvial activities, lacustrine deposits, and harsh climatic conditions, including an aridic moisture regime, hyperthermic soil temperatures, and intense aeolian activity. Soil salinity, exacerbated by water scarcity, is a major issue in the region. High evaporation rates (4000 mm/yr), drought, water deficits, and strong winds have led to the concentration of natural salts like sodium (Na) and magnesium (Mg) in the soil, resulting in the formation of a salic horizon through salinization (Schaetzl & Anderson, 2005).

Socioeconomic Status

Sistan comprises seven cities and around 1,000 villages and nomadic centers. The main city, Zabol, is approximately 1,800 km from Tehran, and this remoteness has affected the region's economy by increasing the net price of goods and services. The population is about 400,000 people, with half engaged in agriculture and domestic activities. Livelihoods in Sistan are heavily dependent on the Hirmand River's water resources for wetland products, services, and agricultural production. As a result, the local and regional economy is highly sensitive to weather conditions, precipitation, and changes in land use and land cover (Dahmardeh Behrooz et al., 2017). Cropland, covering approximately 130,000 hectares, is mainly used for wheat, barley, sorghum, watermelon, melon, and grapes.

One major issue is cereal monoculture, which relies on chemical fertilizers and has low water efficiency. The region's natural vegetation includes species like *Tamarix*, *Salsola*, *Alhagi*, *Prosopis*, and *Desmostachya* (Pahlavan-rad & Akbarimoghaddam, 2018).

Methodology

To examine the complexity of anthropogenic drivers of land degradation and desertification, various socioeconomic factors were analyzed using descriptive statistical analysis to evaluate their links to environmental conditions. These factors influence the environment through non-linear processes and are often part of feedback loops with external variables (Patel et al., 2007). An integrated approach was used, incorporating criteria from multiple sources to identify the causes and drivers of land degradation and desertification in the Sistan region. The analysis of key environmental and socio-cultural variables at the local level provided a framework for policy implementation through interviews, workshops, and questionnaires.

Data collection followed a three-stage research process. Face-to-face interviews were conducted using a questionnaire containing both open and closed questions. The questionnaire development process consisted of three stages:

1. **Literature Review and Workshop**: A review of the literature and a workshop with natural resources experts from Sistan and Baluchestan Province were conducted to identify additional social causes contributing to land degradation and desertification in Sistan. This led to a comprehensive list of social causes.
2. **Categorization of Social Causes**: The identified social causes were classified into six criteria by a panel of experts: social values (3 items), knowledge weaknesses (14 items), cultural issues (11 items), land ownership (4 items), social participation (3 items), and land abandonment and migration (3 items). Each criterion was defined by specific causes (Table 2).
3. **Questionnaire Preparation and Scoring**: A questionnaire was developed based on these social cause criteria, with items scored from 0 (no effect) to 10 (highest effect). The questionnaire was distributed among 24 experts who met three criteria: i) a degree in agricultural sciences or natural resources, ii) experience in natural resources management or desert control, and iii) residency in the Sistan region. A panel of experts reviewed the questionnaire, considering that the relative importance of each social cause might vary depending on regional conditions.

In the third stage, the Analytic Hierarchy Process (AHP) was used to weigh the social cause criteria and their items. A selected group of experts from the Sistan plain conducted pairwise comparisons of each item within a criterion to determine their relative importance. The comparisons were assigned numerical values using a scale of 1–9 (Table 1) in a matrix (Traintaphyllou, 2000). An algorithm based on the matrix's eigenvalue was then used to calculate the relative weight of the social cause items. Finally, the overall score for each social cause criterion was calculated.

$$FS_{ca} = \Sigma W_{ica}.S_{ica}$$

Where FS_{ca}= Final score of social cause criterion a, W_{ica}= weight of the ith social cause item in criterion a, S_{ica}=amount of ith social cause item in criterion a.

Table 1. AHP comparison scale

Intensity of importance	Definition
1	Equal importance
3	Moderate importance of one over another
5	Strong or essential importance of one over another
7	Very strong importance
9	Absolute importance
2,4,6,8	Intermediate values between adjacent judgments
Reciprocal of above	If factor i has one of above numbers assigned to it when compared to factor j, then j has the reciprocal value when compared with i

This stage was repeated for each social cause criterion, ranking the factors that are most significant in Sistan's desertification and land degradation, based on respondents' opinions. Since every social system consists of two sub-dimensions—socio-economic and socio-cultural (Barrow, 2000)—the social causes of land degradation were classified accordingly. In this study, only the weights for socio-cultural factors were calculated.

The methodology was defined and refined through a workshop where six categories of desertification societal drivers were identified, ensuring consistency in data collection among participants. Data were then analyzed using SPSS19 software, and the results were presented.

Results and Discussion

As noted in Section 3, the list of causes (Table 2) was developed through: (i) a review of existing scientific literature, (ii) consultations with stakeholders including experts, land managers, and research groups working on land degradation and desertification issues both at the provincial level and in the case-study area, and (iii) socio-cultural questionnaires designed to assess candidate factors related to the environment. These questionnaires were administered to a range of stakeholders, including experts, local administrators, researchers, and scientists. The resulting list of candidate indicators represents a combination of scientific factors and stakeholder evaluations of relevance.

The societal drivers identified through the participatory workshop were categorized into six groups: social values and dignity, land ownership, knowledge weaknesses, social network deficits (participation), land abandonment and migration, and cultural issues. Table 3 presents the results of the pairwise parametric T-test correlation between these socio-cultural causes.

Key findings include:

- A significant difference was found between several pairs of socio-cultural causes: CL and ML, CL and SP, KW and ML, LO and SV, with correlation coefficients of 0.54, 0.966, 0.553, and 0.969, respectively.
- The strongest correlation (0.422) was between cultural issues (CI) and social values (SV), significant at $P<0.01$. Additionally, CI was significantly correlated with migration and land abandonment (ML) and social participation (SP) at $P<0.01$, with coefficients of 0.328 and 0.319, respectively.
- The correlation between CI and knowledge weaknesses (KW) was significant at $P<0.05$ (0.15), but there was no significant correlation between CI and land ownership (LO).
- KW was significantly correlated with SP and LO at $P<0.01$, with coefficients of 0.366 and 0.317, respectively, and with ML at $P<0.05$ (0.308). However, there was no correlation between KW and SV (0.214).
- LO was significantly correlated with ML and SV at $P<0.01$, with coefficients of 0.447 and 0.339, respectively. The correlation between ML and SV was significant at $P<0.05$, as was the correlation between ML and SP. Lastly, the correlation between SP and SV was significant at $P<0.05$.

Table 2. The list of socio- cultural variables and result of Variance analysis

Acronym	Variable (cause)	Criterion (groups)	Mean	Median	Mode	Std. Deviation	Variance	Minimum	Maximum	Ranking
CI1	untrusting to experts knowledge	Cultural issues	6.1739	7	5	2.479959199	6.1502	2	10	4
CI2	Farm cultivation preference to horticulture	Cultural issues	6.1739	7	7	2.208499571	4.8775	1	9	5
CI3	Un using of wind break around the farms	Cultural issues	6.125	7	8	2.091650066	4.375	3	9	7
CI4	Government dependence and government expectations	Cultural issues	5.3636	5.5	4	2.40129835	5.7662	0	10	21
CI5	ignorance to indigenous knowledge	Cultural issues	6.1667	6	6	2.18028053	4.7536	1	10	6
CI6	Inadequate rural education	Cultural issues	5.5217	5	5	2.390693418	5.7154	2	10	17
CI7	The weakness of demand (the satisfaction of people with the conditions)	Cultural issues	5.5217	6	8	3.422778845	11.715	0	10	18
CI8	Focusing on detail rather than holism and macro	Cultural issues	5.6667	6	6	2.697287956	7.2754	1	10	16
CI9	Shrub cutting from fields and gardens	Cultural issues	5.7391	7	3	3.018388964	9.1107	1	10	14
CI10	monoculture of cereals	Cultural issues	5.875	6.5	8	2.437256119	5.9402	2	10	11
CI11	farrow land cultivation	Cultural issues	6.7083	7	7	1.966660526	3.8678	2	10	2
KW1	Unfamiliar with garden varieties and region conditions compatible	Knowledge weakness	5.75	5	5	2.111047545	4.4565	0	10	13
KW2	ignorance to recycling systems	Knowledge weakness	4.5417	4	3	2.321528107	5.3895	1	8	30
KW3	Un familiar to operating and exploitation systems	Knowledge weakness	5	5	3	2.449489743	6	0	9	23
KW4	Lack of Press and local media	Knowledge weakness	4.6818	5	5	2.766919615	7.6558	0	10	28
KW5	Un using of consultation helps	Knowledge weakness	5	6	8	2.720294102	7.4	0	8	24
KW6	soil salinity due to water logging and chemical fertilizers	Knowledge weakness	4.7727	5	1	2.990967644	8.9459	0	9	27
KW7	firing of residual straw	Knowledge weakness	5.4583	6	7	2.828106859	7.9982	1	10	20
KW8	Intensive animal travelling in the dried wetlands	Knowledge weakness	5.9565	6	5	2.566891662	6.5889	1	10	10

Acronym	Variable (cause)	Criterion (groups)	Mean	Median	Mode	Std. Deviation	Variance	Minimum	Maximum	Ranking
KW9	traditional farming	Knowledge weakness	6.5455	7	5	2.086858489	4.355	2	10	3
KW10	traditional field shelter's destruction	Knowledge weakness	4.4783	4	4	2.761250791	7.6245	0	10	32
KW11	agricultural activity in the wetland vicinity	Knowledge weakness	4.9167	5.5	3	3.006032582	9.0362	0	10	25
KW12	intense exploitation of ground water	Knowledge weakness	5.1818	5	5	2.519190415	6.3463	1	10	22
KW13	Over cultivation in windy and dry seasons	Knowledge weakness	5.9583	6	3	2.678077939	7.1721	1	10	9
KW14	Low use of organic fertilizers	Knowledge weakness	4.7826	5	5	2.430049041	5.9051	0	9	26
LO1	unsettlement of powerful land owners in the region	Land ownership	4.2083	4	5	2.79719062	7.8243	0	10	33
LO2	The situation of powerful land owner properties to wind erosion corridor	Land ownership	4.5652	4	4	2.951518669	8.7115	0	10	29
LO3	land sale to exotic people	Land ownership	3.5652	3	3	2.59064904	6.7115	0	9	38
LO4	Population density especially in critical wind erosion corridors	Land ownership	4.087	4	1	3.175374616	10.083	0	10	35
ML1	The long-term presence of Afghan's immigrants in the region35	migration and land abandonment	4.0952	4	3	2.981690157	8.8905	0	10	34
ML2	Out Immigration of efficient persons	migration and land abandonment	6.087	6	9	3.058713982	9.3557	0	10	8
ML3	Reducing population and closing educational centers in villages	migration and land abandonment	5.7391	6	3	3.17972828	10.111	0	10	15
SP1	Social participation weakness (institutions, councils, etc.)	social participation	5.7917	6.5	7	2.637178444	6.9547	0	10	12
SP2	Non Interesting in joint exploitation, joint stock company	social participation	5.4783	5	4	2.520273528	6.3518	1	10	19
SP3	Lack of system for using of wetland's goods and services	social participation	7.3333	8	8	2.057154359	4.2319	2	10	1
SV1	diminish Respect to agricultural and rural activity	social values	4.0435	4	4	2.439788755	5.9526	0	9	36
SV2	Attachment to inheritance land	social values	4.0417	3.5	5	2.742248628	7.5199	0	9	37
SV3	Low Quality of life in the village	social values	4.5417	4.5	2	2.812691217	7.9112	0	10	31

Based on table.2. The variables that have taken score less than 5.5 (the lowest score was 0 and the highest was 10) have removed based on experts opinion. According to this, 18 variables out of 38 are more effective in the region's LD and D statue.

Table 3. Matrix of Pearson correlation coefficient values associated with the six criteria

Correlations								
		CI	KW	LO	ML	SP	SV
CI	Pearson Correlation	1					
	Sig. (2-tailed)						
KW	Pearson Correlation	.150*	1		.		
	Sig. (2-tailed)	.018					
LO	Pearson Correlation	.185	.317**	1			
	Sig. (2-tailed)	.081	.002				
ML	Pearson Correlation	.328**	.308*	.447**	1		
	Sig. (2-tailed)	.007	.011	.000			
SP	Pearson Correlation	.319**	.366**	.126	.262*	1	
	Sig. (2-tailed)	.008	.002	.304	.032		
SV	Pearson Correlation	.422**	.214	.339**	.484**	.269*	1
	Sig. (2-tailed)	.000	.073	.004	.000	.024	

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

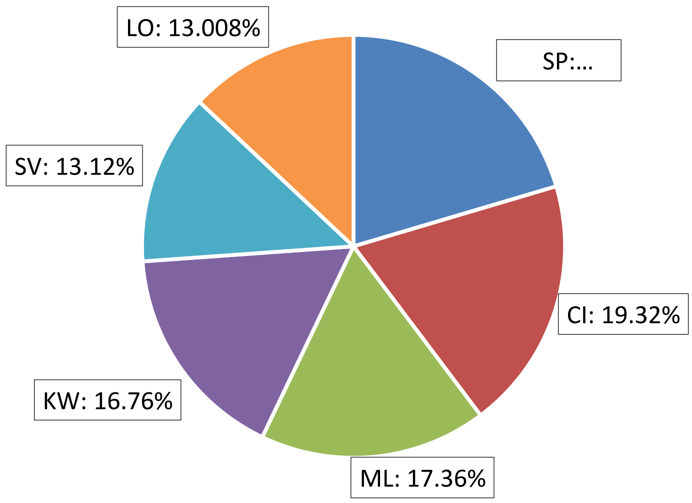

Figure 2. Percentage (%) fraction of six group of socio- cultural criterion

Figure 3 illustrates the average contribution (%) of each socio-cultural group to the total causes of land degradation and desertification in the Sistan region. Social participation (SP) exhibited the highest contribution (20.41%), followed by cultural issues (CI) at 19.32%, land abandonment and migration (ML) at 17.36%, knowledge weakness (KW) at 16.76%, social values (SV) at 13.12%, and land ownership (LO) at 13.01%.

Social Values and Dignity

Social values and dignity contribute 13.12% to the total causes of land degradation (LD) and desertification (D). In developing countries, rural quality of life has become a critical issue (Deller et al., 2001; Hayati & Karami, 2005; Hayati et al., 2006). While rural quality of life criteria are similar worldwide, some are culturally and locally specific (Ahmadvand & Karami, 2009).

Lifestyle changes in many villages have led to a decline in traditional social values, such as the village as a center of production. Today, people can barter for food, and younger generations seek parallel employment with higher incomes than those offered by agriculture and livestock activities. Historically, people relied on their inherited land for livelihood, but now, despite drought and underutilized land, they refuse to cede ownership even to tenants.

These fallow lands contribute to wind erosion, leading to air pollution and exacerbating adverse weather conditions in the Sistan region.

Land Ownership

Land ownership accounts for 13.01% of the total criteria. The lands owned by powerful individuals are prone to wind erosion and require mitigation measures, which landowners often prevent. Many landowners have moved out of Sistan or sold their land to outsiders, worsening the region's dust conditions, particularly during the summer when strong winds blow. This out-migration of landowners results in a diminished sense of responsibility for land conservation, including the management and rehabilitation of degraded lands.

Knowledge Weakness

Knowledge weakness contributes 16.76% to the total causes of LD and D. It includes mismanagement of land and unsuitable activities for the region's conditions. Addressing knowledge gaps through social learning and engaging local people in projects can mitigate these issues. Involving local stakeholders helps identify traditional land-use knowledge and incorporate it into mitigation proposals (Kirkby et al., 2015). Projects fostering discussions between land users can promote best practices in land management, despite existing "lock-ins" (environmental, economic, and social factors) that perpetuate unsustainable activities (Geesen et al., 2015). However, building trust and confidence is crucial, as this process takes time.

Social Participation

Social participation, with the highest contribution (20.41%), refers to the social structure that facilitates knowledge management and social learning. Social structure involves the sum of relationships between group members, including formal rules, cultural norms, and informal social structures (Lopez & Scott, 2000; Ahmadvand & Karami, 2009). Social learning, defined as a change in understanding through social interactions within networks (Reed et al., 2010), is essential for environmental management. The absence of a robust social network to manage land degradation causes and effects is a significant deficit for control measures. Involving stakeholders in land management solutions is increasingly recognized as critical (Geesen et al., 2015), yet social network deficits in the Sistan region contribute to the increased risk of climate change impacts, such as drought and water shortages.

Land Abandonment and Migration

Land abandonment and migration rank third among socio-cultural groups, contributing 17.36%. Land abandonment, a global issue with environmental and socioeconomic impacts, occurs when external drivers or internal dynamics push the agricultural system towards extensification or intensification (Kosmas et al., 2015). Farmers' parallel employment or aging landowners are more likely to abandon agricultural land (Baudry, 1991; Van Doorn & Bakker, 2007). Migration due to environmental degradation, particularly from rural areas, is also a growing concern (Christof et al., 2011). The Helmand Basin in Afghanistan and Iran experienced prolonged droughts between 1999 and 2009, which destabilized hydrological processes and exacerbated tensions between the two countries (Dehgan et al., 2013). Despite government support, including food, medicine, and employment, continuous droughts have forced some residents to leave the Sistan region (Rashki et al., 2013a).

Cultural Issues

Cultural issues contribute 19.32% to the total causes of LD and D and highlight indigenous mismanagement in agricultural practices that lead to soil degradation. Soil, a critical resource supporting most life on Earth, is vulnerable to loss, particularly with agriculture and livestock grazing, threatening food security and even the survival of civilizations (Diamond, 2005; Montgomery, 2007). Desertification, caused by unsustainable agricultural practices, is a recurring problem in drylands, where 44% of global agricultural land is located (MEA, 2005). The conversion of nomadic communities to sedentary lifestyles limits their ability to cope with environmental variability (Geist & Lambin, 2004). Intensive agriculture and clear-cutting of native vegetation exacerbate soil erosion, salinization, and nutrient depletion (Walker & Salt, 2006; Verstraete et al., 2009). Historically, Sistan, part of the Helmand Valley, was known as the "breadbasket of Asia," but poor agricultural practices and failure to restore soil health have made the region more vulnerable to wind erosion.

Results of Analytic Hierarchy Process (AHP)

To identify the most significant causes of land degradation and desertification in Sistan, this study employed a multivariate strategy, including parametric Pearson correlation and the Analytic Hierarchy Process (AHP). Based on statistical analysis from the questionnaire, 18 out of 38 items (those scoring above 5.5, highlighted in Table 1) were identified as key factors. The AHP ranked the following as the most significant factors:

- Lack of systems for utilizing wetland resources (social participation)
- Fallow land cultivation (cultural issues)
- Traditional farming practices (knowledge weakness)
- Distrust of expert knowledge (cultural issues)
- Preference for farm cultivation over horticulture (cultural issues)
- Neglect of indigenous knowledge (cultural issues)
- Failure to use windbreaks around farms (cultural issues).

Conclusion

Desertification processes, both locally and globally, exert significant pressure that can overwhelm the coping mechanisms and adaptive capacities of individuals, communities, and ecosystems (MEA, 2005; Myers & Kent, 1995, 2001). To mitigate these impacts, policies should be implemented to protect the environment and societies from the over-exploitation of natural resources, the erosion of traditional practices, and to foster a culture of sustainable use of environmental goods and services. While conservation is often interpreted as minimizing human intervention in nature, many social-ecological systems rely on human involvement to maintain biological diversity. Thus, reducing or fully abandoning these systems can decrease both biological and cultural diversity (biocultural diversity) (Mauerhofer et al., 2018).

The engagement of all stakeholders in addressing land management challenges is now widely recognized by scientists, advisors, extension workers, and policymakers. Different stakeholders—experts, researchers, and land managers—bring varied knowledge, experience, influence, and motivation to the goal of sustainable land management. In agro-ecosystems affected by desertification, enhancing food security through agricultural improvement, empowering rural populations, diversifying livelihoods, and promoting the sustainable use of resources are crucial steps towards slowing or reversing desertification.

Policies must address the multiple socio-cultural factors contributing to land degradation and desertification, which vary due to differing environmental conditions. Iran's Natural Resources Organization has engaged rural communities in combating desertification, and some efforts have been successful. However, to effectively address and possibly halt land degradation, it is essential for experts to work closely with stakeholders and beneficiaries. This proximity facilitates knowledge exchange, optimizes cooperation, reduces bureaucracy, and fosters trust, yielding benefits for all involved.

In regions experiencing high rates of land degradation and desertification, corrective policies should focus on three key areas: identifying the causes of land degradation in advance, reducing current land degradation, and remedying its effects.

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