

## SOCIAL-ECOLOGICAL SERVICES IN THE RANGELAND ECOSYSTEM: A CASE STUDY OF THE AL-SORRAH RANGELAND RESERVE IN JORDAN

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Submitted final draft: 28 December 2021 Accepted: 6 April 2022

<http://doi.org/10.46754/jssm.2022.07.006>

**Abstract:** The degradation of rangeland protected areas in Jordan due to refugee settlement and climate change directly impacts rangeland well-being and the ecosystem services (ES) it provides. But there is a lack of research and understanding of how human actions and perceptions impact rangeland ecosystems. Therefore, this study aims to investigate how different social-ecological systems (SES) influence human actions and perceptions toward rangeland ecosystems. Using a Multivariate Principal Component Analysis for Mixed data (PCAMIX), we interviewed 100 pastoralists and characterised groups of pastoralists based on their decision-making when grazing inside Al-Sorrah Reserve and their social-economic and environmental attitudes. The results showed a differentiated pattern of SES among the pastoralists. This research paper has identified three pastoralist groups based on their attitudes and perceptions towards utilising SES; based on the PCAMIX eigen values of grazing periods (-0.76), length of grazing inside the reserve (-0.53) and the act of practicing grazing inside the reserve (4.8-6.9). Most pastoralists currently have little incentive to consider the impact of their activities and results suggest that integrating SES into rangeland management and national policy would simplify and enhance knowledge and actions that encourage rangeland management.

Keywords: Pastoralists, local community, attitudes, arid rangeland, rangeland management.

### Introduction

Social-Ecological Systems (SES) are linked systems of people and nature. These systems emphasise that people are an integral part of nature and that Ecosystem Services (ES) are produced through the interactions between ecological and social subsystems of SES (Norgaard, 2010; Fischer & Eastwood, 2016; Palomo *et al.*, 2016). The SES approach distinctly recognises the complexity of the connections and feedback loops that bind people and natural systems together, which is why this approach can be used to generate information and knowledge and formulate sustainable governance solutions regarding ES (Leslie *et al.*, 2015).

Ostrom (2009) proposed a comprehensive SES framework that provides guidelines for assessing the interactions between social

and ecological services that contribute to the management and sustainability of natural resources and ecosystems. The core of this SES framework is the interaction of ecological subsystems with societies and local institutional subsystems that create, modify and supply ES based on the benefits returned to and governed by these social subsystems (Ostrom, 2009; Norgaard, 2010).

Since the Millennium Ecosystem Assessment (2005), progress has occurred in the regional and global literature on how different ecosystem services contribute to and enhance various objectives and components of human well-being (TEEB, 2010; Breslow *et al.*, 2016; Folke *et al.*, 2016; Masterson *et al.*, 2019). In rangeland ecosystems, scholars have explored the link between specific cultural and provisioning ES with human well-being such as grazing, camping and collecting wild plants,

which go beyond aesthetic, recreational and production values.

Some scholars have given additional recognition to the attachment to a place, relational values, spiritual connections and community ownership of certain places or ecosystems (Chan *et al.*, 2016; Pascua *et al.*, 2017). Other scholars have investigated how social structures and means of access determine who benefits from ecosystems in rangelands (Berbés-Blázquez *et al.*, 2016; Biru *et al.*, 2017; Masterson *et al.*, 2019; Azimi *et al.*, 2020).

Accordingly, the features of social-ecological systems develop through the interaction of ecosystem outputs with social and ecological services (Reyers *et al.*, 2013; Huntsinger & Oviedo, 2014; Palomo *et al.*, 2016). Various SES generate diverse ES in different quantities and combinations based on different attitudes and perceptions of human well-being. In other words, each ecosystem can be connected to distinct “bundles” of ES (Al-Assaf *et al.*, 2014; Depellegrin *et al.*, 2016; Hamann *et al.*, 2016). Examining rangeland ecosystems as a production ecosystem from an SES perspective, this research paper expands substantially on current assumptions towards a natural ecosystem that provide limited services.

The wide range of ecological ecosystems and the diversity of ES from different ecological zones have made Jordan’s biodiversity one of the richest in the Middle East and the world. One of the most widespread ecological zones is the arid “Jordan Badia”, rangeland that accounts for 80% of Jordan’s land.

The social-ecological system in the Jordan Badia is composed of its ecological processes and the social value that pastoralists grant to these services. While the Badia is a harsh and delicate environment, it provides local communities with substantial ES such as natural fodder, medicinal plants and watersheds that receive rainfall, yield surface water and replenish groundwater throughout the region to the east and south of the western Jordan highlands. The local population primarily depends on livestock to make a living.

The rangeland has been termed an SES because human activities play a substantial role in shaping this unique ecosystem. An understanding of the rangeland can reduce and minimise the failure of direct prescriptions of the current management (Huntsinger & Oviedo, 2014).

There has been a significant reduction in Jordan’s rangeland area due to the Syrian civil war, refugee settlement in rangeland areas, insufficient rangeland management, poor regulations and a lack of information on or assessments of current threats to the north-western part of Jordan (Sawalhaha *et al.*, 2018). The estimated forage yields in the Badia have declined to less than 10% of the rangeland’s potential, leading to a reduction in the amount of natural fodder for livestock in the rangeland and forcing local communities to depend on livestock fodder from markets, increasing the cost of raising the livestock.

These high costs result in less profits from raising livestock for communities that are already struggling. Previous research has emphasized the limited availability of income sources and agricultural activities for local communities that mainly depend on the direct income and benefits that come from breeding small ruminants (Al-Karablieh, 2010; Sawalhaha *et al.*, 2018). As of yet, no scientific studies have been conducted in Badia to assess the attitudes and perceptions of the local community towards land management for the sake of biodiversity conservation, which could increase tree cover and consequently forage yields.

Looking into the thoughts of local community is critical to delineating the boundary and an adequate buffer zone of the reserve area, preparing a management plan and enhancing governance by recording and communicating possible conservation strategies and participatory management plans for the reserved and protected areas in Badia (Andrade & Rhodes, 2012).

The governance of PA in the Badia requires the inclusion of local communities, which is likely to be a key determinant of their level

of compliance with PA conservation strategies. Here, we explore the pasture as an SES generated by the rangeland and investigate the trade-offs between utilizing and conserving rangeland reserves. Local community know-how, perceptions and attitudes are influenced by factors such as their awareness of the PA, education level, direct and indirect services of protected areas and benefits of conservation projects (Cumming *et al.*, 2015; Hamann *et al.*, 2016; Biru *et al.*, 2017). Understanding these factors is critical to improving the relationship of the local community with regard to protected areas such as the rangeland reserves, as it enhances peoples' awareness of the importance of rangelands for biodiversity and conservation in and around the protected areas.

Here, we use the SES framework introduced by Ostrom (2009) to investigate how different SES influence human actions and perceptions towards the conservation of rangeland ecosystems. The objectives of this study are to: (1) Identify social-ecological bundles of pastoralist groups based on their attitudes and perceptions towards ecological services in the rangeland reserve and to (2) Elucidate how perceptions towards ecological services vary

among pastoralist groups and the degree to which social-demographic factors and perceptions are associated with their behaviour in the reserved area.

**Materials and Methods**

**Study Site Background and Description**

The Jordanian Badia is home to approximately 380,000 people (6.5% of Jordan's total population) (Abu Amoud *et al.*, 2016), providing them with much-needed ecological services such as grazing and provisioning desert plants with high medicinal value (for example *Artemisia* and *Achillea millefolium*). Livestock production is the main activity in these areas. Sheep and goats depend on the forage in the semi-desert rangelands produced during the short periods following rainfall. The Agriculture Ministry has established 34 reserves in the Badia to protect and manage the rangeland's biodiversity and conserve the ecosystem.

One of the oldest (established in 1975) and largest (area  $\approx$  400 ha) rangeland reserves is the Al-Sorrah Reserve, which is located in the Al-Mafraq Governorate (Figure 1). The Al-Sorrah Reserve is surrounded by four communities, the

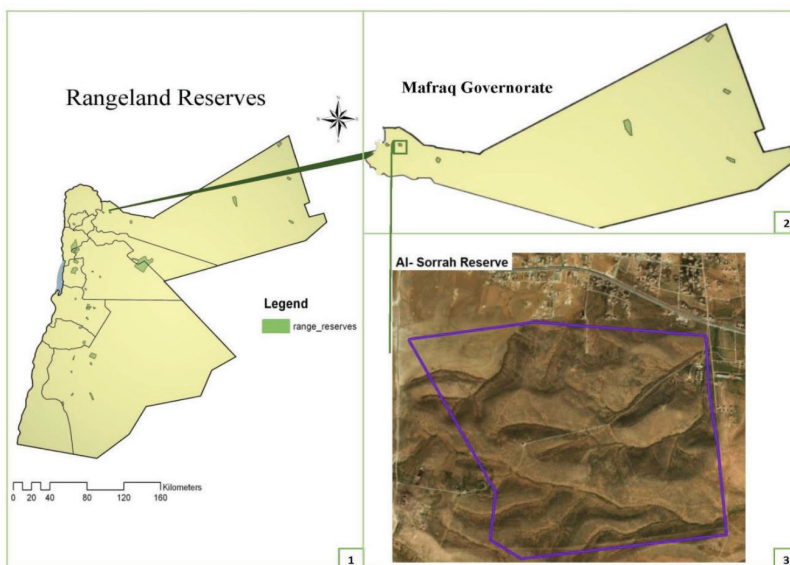


Figure 1: Distribution of range reserves along rain lines (Source: Agriculture Ministry/Rangelands Directorate and Badia Development, 2014)

closest and largest of which is the 'Al Mansoura village', with a total population of 6,128 people (DoS, 2018).

According to the most recent census on livestock, the main communities close to the reserve own almost 16,000 sheep and 8,000 goats (MoA, 2014).

The reserve is under the complete control of the Agriculture Ministry through the local directorate in Al-Mansoura village, which has conducted successive rehabilitation and restoration activities on the reserve.

Although legal grazing on the reserve ceased completely in 2006, illegal grazing in and around the area (Al-Sorrah Reserve) has continued and destroyed the reserve's biodiversity and severely damaged the overall ecosystem.

The local authorities have tried through several projects to involve the local communities, especially pastoralists, in restoration activities to ensure the sustainability of biodiversity on the reserve, but the local communities haven't always accepted their involvement in reserve management.

### ***Sampling and Survey***

The survey collected information from local communities surrounding the Al-Sorrah rangeland reserve, including the villages of Al Gadeer, Al Mansoura, Al Hamra and Mager al Serhan. According to the Agriculture Ministry Veterinarian Services Department, only 250 pastoralists hold large flocks of livestock (equal to or greater than 150 heads of sheep and goats) in the study area. Pastoralists with large flocks depend substantially on fodder from natural grazing but do not have enough grazing area in the legal zones to do so at the Al-Sorrah Reserve.

A sample of 100 livestock breeders was determined to be a convenient sample size for representing the local communities at the reserve site. The communities were considered homogenous and there was no specific profile for

selecting respondents beyond their willingness to participate in this study. Respondents were targeted at random and data was collected through face-to-face meetings and focus group discussions with pastoralists and governmental workers in the region using a structured questionnaire.

The questionnaire was developed and pre-tested to ensure its consistency and efficiency in collecting information. This questionnaire aimed to collect information on the social-economic status of the local community and an ecological assessment of the area by its resident community. The questionnaire was divided into three parts, categorised by the following topics: (1) Household characteristics and economic status, (2) Ecological services provided by the Al-Sorrah Rangeland Reserve and (3) Development of the community and the reserve.

Ostrom (2009) proposed a general framework for analysing the sustainability of the social ecological system that helped this researcher understand the complex interactions between the different systems and within the systems themselves as well as the scales of natural resource governance (Epstein *et al.*, 2013). This framework is a holistic model that seeks to analyse social, economic, ecological and policy aspects at different levels and in different subsystems. This research paper employed this framework in a bid to understand the interactions of pastoralists with the rangeland reserve, focusing on the attitudes and interests that could provide information on their systems as a part of the whole system at large.

Ostrom's framework is based on defining the interactions between resource units, resource systems, governance systems and end-users that delivers outcomes within their social, economic and political conditions. Ostrom proposed 53 second-level variables to establish the main features of the subsystems, though an additional level of variables is left open and undefined to allow for a deeper analysis of the social ecological system (Ostrom, 2009).

**Statistical Analysis**

This research paper used the multivariate Principal Component Analysis for mixed data (PCAMIX) technique. This technique allows both binary and continuous data to be integrated by combining the standard PCA for quantitative variables with the standard Multi Correspondence Analysis (MCA) for qualitative variables in special cases (Torralba *et al.*, 2018). The first three components of the PCAMIX were interpreted following the Kaiser-criterion (eigenvalues <1) (Garrido *et al.*, 2017).

This research paper then goes on to perform a correlation analysis using the respondent’s index between their pastoralist group’s outputs from PCA factor loading and their driving forces for conservation and management. The significant variables were used to explore the driving forces of the three groups’ dynamics in the rangeland ecosystem. this data was then used to group each participant into one of three groups, coding them based on their work experience, level of education, residency period, for the purpose of breeding livestock, membership with local associations, reasons for grazing in the reserve, observed changes in specific plant species, conflicts between stakeholders, conflicts over grazing areas and participation in rangeland reserve development.

The different types of conflicts were defined as conflicts related to rangeland (conflicts over grazing areas outside the village and the reserve), conflicts among stakeholders (conflicts that occurred between pastoralists and governmental administration working in and around the reserve) and conflicts over grazing areas (conflicts that occurred among pastoralists that depend on grazing areas inside the reserve).

The XLSTAT software (Addinsoft, version 9.0) was used to calculate the eigenvalues for the survey variables.

**Results**

**Pastoralists’ Description and Rangeland’s Services**

The sample of pastoralists provided social and economic information about their households and in the communities surrounding the rangeland reserve. This information was a substantial source of primary information from the community in the area under review. Of the survey respondents, 87% were males with an average age of 56.4 years ( $\pm$  11.7) and 68% of respondents (as the head of the household) worked primarily as livestock breeders and the rest were retired with a fixed monthly retirement income (Figure 2). All the pastoralists followed

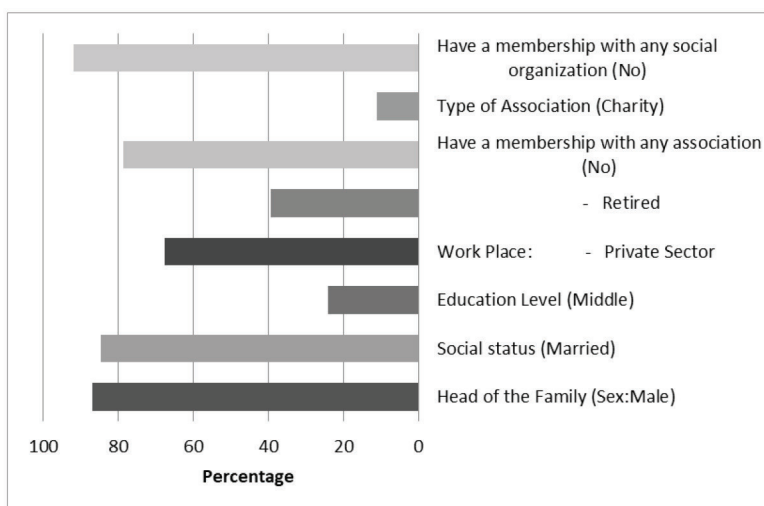


Figure 2: Pastoralists’ characteristics and rangeland’s services around AI-Sorrah reserve, Jordan



a semi-nomadic production system, where families were settled in the villages and the responsible family member, typically the head of household, travelled with the livestock. These herds mainly consisted of sheep and goats.

Respondents averaged four years of education ( $\pm 2.1$ ) and typically had 25.7 years of experience ( $\pm 12.8$ ) with livestock breeding. Many had resided in the area for about 40 years ( $\pm 14.4$ ). However, a few pastoralists had established connections with any kind of association, only five respondents were actively involved in social charity.

The average family size was eight people, with five people over the age of 18 in the family. Only three respondents declared that they had a fixed job, with one person working in agricultural activities and the other two people working on other off-farm jobs. The respondents indicated that the lack of jobs and low salaries were the main reasons for unemployment.

The pastoralists mentioned several challenges with livestock breeding. The most common challenge involved the low availability of native grazing areas, which forces breeders to depend on supplementary fodder from markets that cost a lot of money. Respondents indicated they have intensive interactions with the rangeland reserve, with 85% of them practicing daily grazing for about 5.5 hours ( $\pm 1.1$ ) in the reserve for 10 months of the year. The reserve's unique biodiversity and location were the main reasons pastoralists chose it for livestock grazing. 67% of the pastoralists noticed changes in the availability of grazing plants from year-to-year.

Of the pastoralists that noticed a reduction in specific plant species, many cited low rainfall levels as the main reason for deteriorating vegetation cover, which places additional burdens on the pastoralists to provide adequate grazing for their livestock. Most of the pastoralists collected native wild plants for domestic consumption based on local knowledge of edible, medicinal plants. The reserve was not considered a source of fuel-wood for heat in the winter.

### ***The Social-ecological Bundles of Pastoralist Groups in the Rangeland Ecosystem***

This study identified three groups of pastoralists by comparing the indicators of groups' preferences towards their coexistence with and utilisation of resources in the Al-Sorrah protected area (Table 1). The projection of groups' preferences in the PCA for mixed data reduced the variability in the groups' preferences to three components, absorbing 64.26% of the variability and giving them an eigenvalue indicator larger than one (Table 1).

The three pastoralist groups were identified based on their preferences towards maximising utilisation of the pastureland (Utilisation group), cooperation with rangeland management (Cooperation group) and concerns for the rangeland ecosystem (Consideration group).

The first axis identified the positive and negative parameters of group perceptions towards reserve management and governance. On this axis, the utilisation group was associated with positive attitudes from pastoralists towards not practicing grazing activities in the reserve. They demonstrated a weak dependency on natural grazing for their livestock's nourishment, as the grazing periods and the level of grazing efficiency were negatively associated with the pastoralists' willingness to maximise utilisation of the grazing areas. Pastoralists seeking better grazing did not depend on long grazing periods and they easily leveraged the capacity of the rangeland ecosystem for open grazing. Pastoralists of this group likely reside in areas far away from the Rangeland Protected Area (RPA) and owned a small flock livestock flock. They also likely have grazing alternatives near pastures and do not travel a long distance to use this pasture, which encourages these pastoralists to use alternatives to the RPA as they are available for their relatively small flocks.

The second axis identified pastoralists with a strong motivation to cooperate in rangeland management, which was positively associated with their desire for social cooperation and consideration for ecosystems. This axis revealed few, negative and low associations in relation to

Table 1: Results of the PCAMIX for projecting social-ecological bundles in a rangeland ecosystem

Parameter	Groups Preferences Towards		
	Maximizing Utilization of Pasture Land (Utilization)	Cooperation in Rangeland Management (Cooperation)	Concerns for the Rangeland Ecosystem (Consideration)
Grazing hours	-0.333	0.417	<b>-0.528</b>
Grazing periods	<b>-0.755</b>	-0.204	0.076
Level of social cooperation	-0.470	<b>0.596</b>	0.212
Level of consideration for ecosystem	-0.408	<b>0.577</b>	-0.270
Level of grazing efficiency	<b>-0.730</b>	-0.407	-0.183
Practice grazing within the reserve	-0.246	-0.210	0.107
Do not practice grazing within the reserve	<b>1.377</b>	0.837	-1.057
Refused to declare if they practice grazing within the reserve	-0.277	<b>4.861</b>	<b>6.991</b>
Eigenvalue	1.940	1.451	1.108
Variability (%)	27.708	20.726	15.828
Cumulative (%)	27.708	48.434	64.262

the grazing efficiency and grazing period of the pastoralists in this group.

All the Cooperation groups' pastoralists were unwilling to declare if they practiced grazing within the reserved protected areas (RPA), reflecting the complicated situation they deal with; members of this group admitted that the reserved protected areas are government property while recognising it as the nearest pasture and water source to their residence for livestock. Nevertheless, due to its location and rich biodiversity, pastoralists of this group felt forced to use this pasture, due to the limited availability of other nearby pastures and weak surveillance of the reserved protected areas.

The third axis identified pastoralists expressing mindfulness and consideration towards the rangeland ecosystem. Several parameters were strongly associated with the Consideration group's attitudes such as fewer daily grazing hours for their livestock and a

positive association with denying practicing any grazing activities within the reserve.

This group of pastoralists reflected positive associations with social cooperation. Pastoralists from this group are expected to own small flocks and likely live on one side of the reserve. From an economic point of view, it is not feasible for them to shepherd a small flock in a large area like the reserve where no water sources are available.

#### *Linkages between Pastoralist's Groups and Perceptions of the SES*

We found powerful positive and negative correlations between the identified pastoralist group's social, economic, governance and biophysical drivers (Table 2). This study applied a Multiple Factor Analysis (MFA) to link social ecological systems with pastoralist's group tendencies, which absorbed 58% of the variability in the first three axes and revealed a complex and distinguished pattern

of interactions between pastoralist’s groups practice rangeland conservation and effective and the SES and groups’ willingness to management (Figure 3).

Table 2: Correlation (Pearson) between the management-related ES trade-offs and SES drivers of change. Figures in bold indicate strong correlations ( $r > |0.3$ )

Parameter	Groups Preference Towards		
	Maximizing Utilization of Grazing System (Utilization)	Cooperation in Rangeland Management (Cooperation)	Concerns for the Rangeland Ecosystem (Consideration)
Work experience	<b>0.545</b>	<b>0.654</b>	-0.101
Age	<b>0.607</b>	<b>0.679</b>	-0.012
Education level	<b>-0.453</b>	<b>-0.474</b>	<b>0.348</b>
Residency period	<b>0.586</b>	<b>0.654</b>	0.099
Purpose of breeding livestock	<b>0.433</b>	-0.183	<b>-0.597</b>
Membership at local association	<b>-0.412</b>	-0.071	0.060
Reasons for grazing in the reserve	0.077	<b>0.331</b>	0.114
Conflicts related to rangeland	<b>0.829</b>	<b>-0.477</b>	0.211
Observed changes in specific plant species	-0.005	<b>-0.309</b>	<b>-0.374</b>
Conflicts among stakeholders	<b>-0.829</b>	<b>0.477</b>	-0.211
Conflicts over grazing areas	<b>0.829</b>	<b>-0.477</b>	0.211
Participation in reserve development	0.077	0.013	<b>0.728</b>

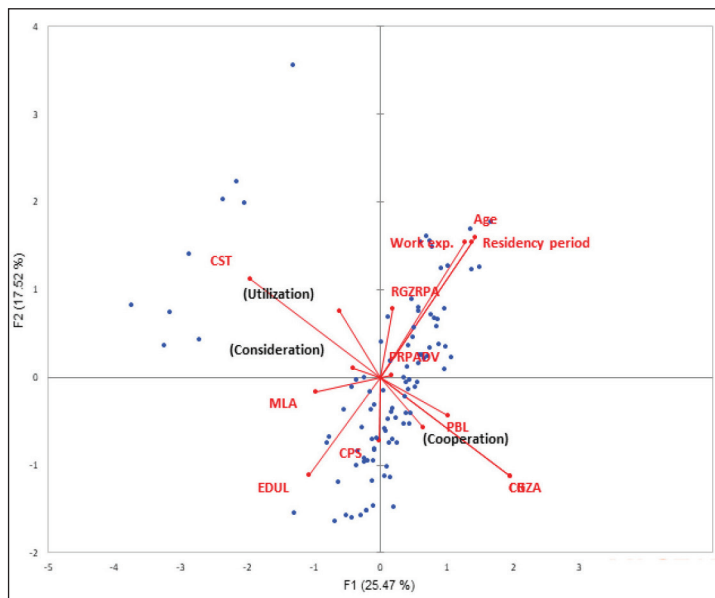


Figure 3: Biplot of the first two axes of the MFA (43% of the variability absorbed) presented by observed coordinates. F1 and F2 represent the coordinates of variation among groups and factors. The colour of the labels indicates blue for observations, black for groups of management-related ES trade-offs and red for SES drivers



The parameters are:

Work exp. = Work experience

EDUL = Education Level

Residency period = Residency period

PBL = Purpose of Breeding Livestock

MLA = Member at Local Association

RGZRPA = Reasons for Grazing in RPA

CPS = Changes in Specific Plant Species

CST = Conflicts among Stakeholders

CGZA = Conflicts over Grazing Areas

PRPADV = Participation in RPA Development

The utilisation pastoralist group was negatively associated with conflicts among stakeholders, likely due to their low potential for having conflicts with the government administration of the reserve and other stakeholders. Meanwhile, they revealed a robust and positive correlation with perceptions towards the existence of conflicts over grazing areas and rangelands.

The members of these groups tend to be old and have extensive work experience in livestock herding, though they have an elementary education level. According to the associated properties and perceptions of this group, most of the members believe that government land is common land and any person will utilise it regardless of the status of biodiversity cover. Yet, the pastoralists plan to maximise utilisation of the pasture in the short term as they did not reflect any concerns for the future of the reserve.

The perceptions of pastoralists in the Utilization and Consideration groups were negatively associated with high incidents of conflict among stakeholders. Pastoralists in the Cooperation group had negative associations with breeding livestock, the majority of which were for trading and had conflicts over grazing areas. Any initiative for social cooperation in pasture ecosystems held a strong correlation with animal breeding for trading and the existence of spaces for sustainable community cooperation.

Additionally, extensive work experience, age and length of residency near the Al-

Sorrah reserve were all positively associated with pastoralists being more inclined towards utilisation and cooperation with conservation initiatives in the rangeland ecosystem. Meanwhile, pastoralists from the Consideration group were the only ones to demonstrate a strong positive correlation with their opinions towards grazing in a close and rich pasture and their willingness to participate in reserve development.

Some pastoralists revealed positive attitudes towards cooperation in rangeland management and concerns about the rangeland ecosystem (Table 2 and Figure 2), yet, these attitudes were inversely associated with a strong willingness to be a member at a local association and with a higher education level. They also reflected a weak impression towards observing any changes in specific plant species. Unexpectedly, the pastoralists' education and knowledge of the ecosystem did not enhance their willingness to get involved with any cooperative conservation efforts; we could question current acting policies for supporting the establishments of Community-Based Organisations (CBO). In Jordan, the CBO's is recognised for strengthening cooperation and enhancing awareness of restoration efforts among young and educated pastoralists.

The farmers tend to hire herders to shepherd the flock and to enhance pasture utilisation these herders travel farther inside this large rangeland reserve. This also helps them avoid any conflicts over rangeland with other stakeholders and prevents any kind of mixing with other flocks, avoiding animal diseases. Pastoralists who expressed consideration for the rangeland ecosystem were in the group that was least likely to observe a decrease in specific plant species in the rangeland but held an extreme willingness to participate in the reserve's development plan. Individuals in this group had less work experience and were younger and as a result, had little knowledge of specific changes in the plant cover of the rangelands.

## Discussion

Our results show that the pastoral ecosystem is a single commodity production ecosystem limited by the varieties of ecological systems available in such a harsh environment, many of which are vital to the survival and subsistence of the poorest groups in the community (Dougill *et al.*, 2010). Livestock trading was the primary income source for the families living near the Al-Sorra reserve, which indicates the importance of the pastoral ecosystem to the livelihoods of the local communities (Al-Karablieh, 2010; Haddad, 2014), especially in terms of savings in cost, effort and time securing fodder for livestock. Nevertheless, the pastoral ecosystem showed a consistent lack of management and sustainability for a moderate production ecosystem focused on grazing, in addition to provisioning medicinal plants and firewood during the short periods of the year.

Historically, local communities support rangeland restoration and rehabilitation, specifically for the re-introduction of the traditional grazing approach in specific pasture areas, seeking ecosystem integrity through nomadic lifestyles. This approach had reduced the level of conflicts among different beneficiaries of the ecosystem (Haddad, 2014). In other words, the successful management of the reserve area is considerably dependent on the acceptance, commitment and cooperation of local communities to sustainable plans (Dong *et al.*, 2017; Zhou *et al.*, 2019).

However, the pasture ecosystem is currently beyond government attention and pastoralists are reducing livestock breeding due to the cost and long period of dependency on feed, which reduces the marginal profits from livestock breeding. The weak movement to protect rangeland reserves (Abu Amoud *et al.*, 2013; Haddad, 2014), as presented in this case study of the Al-Sorra reserve has contributed to the reduction in livestock breeding.

This research aimed to describe and compare the pastoralists' groups based on their attitudes and perceptions towards social ecological systems (SES) in the rangeland

reserve. The research applied factor analysis to identify distinct bundle types and investigated whether different pastoralists' bundles and their perceptions towards SES reflected different combinations of pastoralists' attitudes towards the rangeland reserve. This approach is usually used to identify specific bundles of human-environment interactions, which can be utilised in enhancing governance of extended and production-limited ecosystems such as the rangeland ecosystem (Raudsepp-Hearne *et al.*, 2010; Su *et al.*, 2012; Haddad, 2014; Al-Assaf, 2015; Yang *et al.*, 2015; Depllegrin *et al.*, 2016).

This study found three distinct pastoralist groups, which overlapped with the SES in the reserve area. The identified groups were strongly associated with perceptions towards biodiversity conservation and ecosystem management. Thus, the overlapping of pastoralists groups and SES bundles could be employed as proxies for ecological services utilisation and tackling social-ecological dynamics in data-poor areas (Meacham *et al.*, 2016; Hamann *et al.*, 2016; Torralba *et al.*, 2018).

Meanwhile, the SES can be measured by the direct use of and perceptions towards local ecological services (Martín-López *et al.*, 2012; Reyers *et al.*, 2013; Al-Assaf, 2015; Hamann *et al.*, 2016).

The main distinctions between the pastoralist groups were the bundle of SES associated with each group. Pastoralists' grazing practices inside the Al-Sorra reserve explained their preference towards utilisation, cooperation and consideration in the rangeland ecosystem. Pastoralists identified as seeking to maximise utilisation of the pasture ecosystem overlapped with the pattern of grazing. In other words, high levels of ecological services utilisation within the local community almost exclusively imply relatively low overall well-being (Hamann *et al.*, 2016).

Still, a group of pastoralists expressed a strong degree of consideration for the reserve. Their low level of ES utilization reflected an understanding of the need for an ecosystem to recover and for periodically grazing based on

the ecosystem's integrity and land cover. The results reflected that these pastoralists deny grazing inside the reserve because they are afraid of sanctions for breaking the law, even though there are no effective sanctions for utilizing the reserve for grazing. There is a common opinion that the rangeland ecosystem hosts the poorest and most vulnerable communities who depend upon their immediate natural environment to meet their basic needs (MEA, 2005; Angelsen *et al.*, 2014).

Local communities in the Badia have very limited job opportunities and breeding livestock is at the core of their culture and heritage. The degree to which pastoralists exploit pasture by all accounts is influenced by their attitudes towards the reserved areas, reflecting the consolidation of community efforts through cooperation in rangeland management, specifically in poor areas (Biru *et al.*, 2017).

Several previous studies highlighted the importance of social-demographic factors and other relevant perceptions in understanding the behaviours of a group of people in an ecosystem (Hamman *et al.*, 2016; Depllegirin *et al.*, 2016; Biru *et al.*, 2017).

This study has discovered that specific social-demographic factors and opinions formed each pastoralist group (Table 2). To promote trade-off thinking, this study argues that identifying SES and pastoralist groups, including attitudes and social-demographic drivers and perceptions, might be a useful way to move forward in enhancing restoration plans and governance of rangeland reserves. Specifically, this paper argues that this is useful for: (1) Reforming regulations and enforcing government amendments over rangeland reserve management and restorations, (2) Assessing the power relations among pastoralists near reserve areas in the rangeland ecosystem, (3) Integrating social-demographic characteristics and perceptions to involve local communities in the rangeland development process, (4) Detecting and valuing conflicts, as different pastoralists might value the same SES but for different purposes with different decision outcomes and

(5) Local communities that have proved to have limited job opportunities and access to financial support, forcing them to maximise the utilisation of the pasture to reduce costs and avoid long waiting periods for purchasing fodder supplies.

## Conclusion

Exploring rangeland services has brought to light the complexity of identifying SES within a data-poor area. However, the SES framework used in this study provided a promising tool for describing human interactions with pasture ecosystems and these human's traditional and environmental values.

Even though the pastoralists have traditional and tribal connections, they presented different perceptions reflecting variations in their behaviour when it comes to the surrounding natural ecosystem. Using SES bundles to identify groups based on their perceptions and attitudes in pastoral management was enough to capture substantial variation in pastoralist groups' preferences across the reserve, which may offer a relatively accurate way of exploring and assessing their behaviour and perceptions, an understanding of which can be used to enhance the governance and conservation of rangeland reserves.

Moreover, the results emphasised the role of social-demographic factors in shaping pastoralists' perceptions and attitudes, as well as the connections between grazing dates and durations, social cooperation, levels of grazing efficiency and practicing grazing within the reserve. This suggests that different sets of practices and attitudes can capture large proportions of social-ecological variation within the rangeland ecosystem.

In developing countries, national policies such as rangeland policies aim to conserve the rangeland and promote pasture management. The results of this research suggest that integrating SES in rangeland management and national policy would simplify and enhance knowledge and actions that encourage rangeland management, where most pastoralists have

weak incentives to consider the impacts of their activities.

This requires acknowledgment and integration between different roles and perceptions from all beneficiaries and managers to achieve fair utilization levels of the SES in rangeland reserve.

This knowledge emphasises the importance of communicating with pastoralists and the local community to ensure the success and sustainable protection of the rangeland reserve. Considering SES should be a critical component in any rangeland development initiative. Further research is required to highlight the driving forces behind climate change on the social ecological systems in rangelands and on the management of such reserves.

### Acknowledgements

The authors would like to thank the Royal Botanic Garden Jordan founder Princess Basma Bint Ali for continuously supporting the conservation of plant biodiversity and related research and the staff of the Royal Botanic Garden Jordan for facilitating the research at the site. We are very grateful to the pastoralists from the villages surrounding the Al-Sorrah reserve for sharing their time and information. Thanks, are also extended to Ms. Al-Zahraa Abu Kashef for preparing the map using Geographic Information System tools.

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