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Economic Assessment and Community Management of *Prosopis juliflora* Invasion in Sweimeh Village, Jordan

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Abstract: Invasions by invasive alien species (IAS) are recognized as one of the largest threats to earth's ecosystem services and represent rapidly growing economic costs as they damage local ecosystems and force surrounding communities to divert resources towards IAS management and control. The study objectives were to assess the economic impacts of a *Prosopis juliflora* invasion in Jordan and gauge community preferences for management plans. The study was conducted in Sweimeh, Jordan Valley using a combination of focus groups and randomized interviews with 203 local households. Direct-use values for products derived from *P. juliflora* and direct costs owing to *P. juliflora's* presence have been calculated. A binary logistic regression model was then developed to predict the households' preferences between two policy responses: *P. juliflora* management or complete eradication. The results revealed the dualistic role of *P. juliflora* in household livelihoods: it was widely used for firewood, fodder, and charcoal offering benefits valued at JOD 2165 per household/year (JOD 1 = USD 0.71). At the same time, the invasion reduced household welfare by taking over arable lands and injuring humans and animals. Consequently, the income lost as a result of the invasion was estimated by JOD 1410.5 per household/year. As a result, two-thirds of respondents choose the option of *P. juliflora* invasion management. Only respondents' monthly income and perception of *P. juliflora's* impact on the prevention of soil erosion were significant predictors of respondents' preferences for the management plans. In conclusion, more coordinated responses between policy makers, institutions, and local communities are required to mitigate the negative impact of *P. juliflora* invasion.

Keywords: benefit–cost analysis; *Prospois juliflora*; invasion management; binary logistic regression

1. Introduction

Invasive alien species (IAS) are species that, when introduced and/or spread outside their natural past or present habitat, threaten ecosystems' biodiversity and can harm the economy and even human health [1–6]. Invasions by alien species are recognized as one of the greatest threats to earth's ecosystem services (ES) and represent rapidly growing economic costs due to the damage they cause

and management they require [1–3]. Thus, effective policy and management responses are essential to address the multiple threats posed by IAS. Such responses require support from local communities, land managers and environmentalists and should take into account different ecological, social, economic and livelihood considerations [7–9].

The discussion surrounding the costs and effects of IAS, and the underlying human influence in moving species around the world, has been ongoing for millennia [4,10]. In the last few decades, the constant documentation and research produced regarding IAS have highlighted difficulties in identifying invasions and thus hint at the possible challenges conservation and restoration efforts may face [4,9,11]. Further debate revolves around the magnitude of economic costs resulting from IAS invasion, the levels of expenditure needed for management, the effectiveness of management, and the feasibility of management from environmental and economic standpoints [12,13].

Although the dichotomous "friend or foe" designation of IAS has been broadly discussed [14,15], the perceptions and opinions of peoples affected by IAS invasions in their local ecosystems and the invasions' effects on the ES they depend on for a living were rarely studied. To rectify this, a number of lines of inquiry should be raised to determine how rural families view IAS, including inquiries regarding benefits and costs they perceive having experienced, the impacts of IAS on their main economic activities and health status and the types of risks they have faced due to IAS in their communities [16]. The lack of information on the socioeconomic impacts of IAS has been singled out as a major barrier to implementing comprehensive zonal management projects. Therefore, it is crucial to understand the reasons for and costs of IAS introductions, beneficial uses of IAS, ecological effects of IAS, scales of IAS invasions, perceptions of the invasion and potentially contentious issues when creating sustainable management plans [17]. Successful sustainable development plans could reduce the overall expenditure needed to address the effects of an invasion by diminishing losses to human health, agriculture, and forestry and by preserving natural systems and the services that they provide. Simply put, the IAS, as a part of the broader socio-ecological systems in which they are located, are part of systems that shape human utilization and perceptions of the surrounding ecosystem services. Successful IAS management is based on understanding all stakeholders—including local communities—and inducing them to act [18].

Local communities are most directly exposed to IAS, where they incorporate IAS into their livelihoods. Therefore, elucidating these links would provide important insight for understanding IAS's roles in socio-ecological systems since people perceive the effects of IAS according to the space, time, and social groups/status (i.e., gender, wealth status, and residency period) to which they belong [19–22]. Moreover, households and communities vary in their dependency on and usage of invasive species [23].

Knowledge about IAS's roles in socio-ecological systems provides implications for policy formulation and external response plans. In other studies, local people demonstrated a receptive response to the IAS in the surrounding ecosystems since, even though some households might be negatively exposed to IAS, other households benefit from ecosystem services derived from IAS. *P. juliflora* invasions forced local residents to incur a range of costs or ecosystem disservices that lead to reduced human welfare and household wellbeing through the loss of household assets and livelihood outcomes [4]. Other households benefit from ecosystem services derived from IAS [4,21,24]. For instance, some studies identified some IAS as important sources of food, medicine, firewood, and aesthetic value [25,26].

Prosopis is an evergreen shrub or tree belongs to *Fabaceae* family and native to Mexico, Central, and South America [27]. *Prosopis* trees are 15 m tall with a 10-m spread and have an invasive root system (water-hungry roots) which can be very destructive [28]. Due to its tolerance mechanisms to biotic and abiotic stress, *P. juliflora* was introduced to different parts of the world with an aim of providing benefits to rural communities and surrounding ecosystems (e.g., providing fuel, wood, charcoal, construction material, and supporting soil in degraded ecosystems) [28]. *P. juliflora* is a multipurpose tree/shrub with verifiable benefits and services as such as the provision of fuel [29,30], shelter [30] and fodder for

livestock and broilers [31] as well as its medicinal uses and ability to pollinate [32]. *P. juliflora* wood has been classified as hardwood and their wood is considered durable regarding decay resistance. However, the shrubby form of *P. juliflora* leads to irregular grain or knots across the main stem and, consequently, their use as a building material and carpentry can be challenging [33].

Nevertheless, several research studies report concerns regarding the negative effects of *P. juliflora*. These negative effects include, but are not limited to posing hazardous threats to humans [31], avifauna [34], and cattle [35] and causing the loss of biodiversity and native species [36,37]. Currently, *P. juliflora* invasion is widely reported worldwide (Figure 1), including Yemen, Sudan, Kenya, Ethiopia, South Africa, India, and Pakistan [27]. In fact, *P. juliflora* is listed on the IUCN world's 100 worst IAS [27].

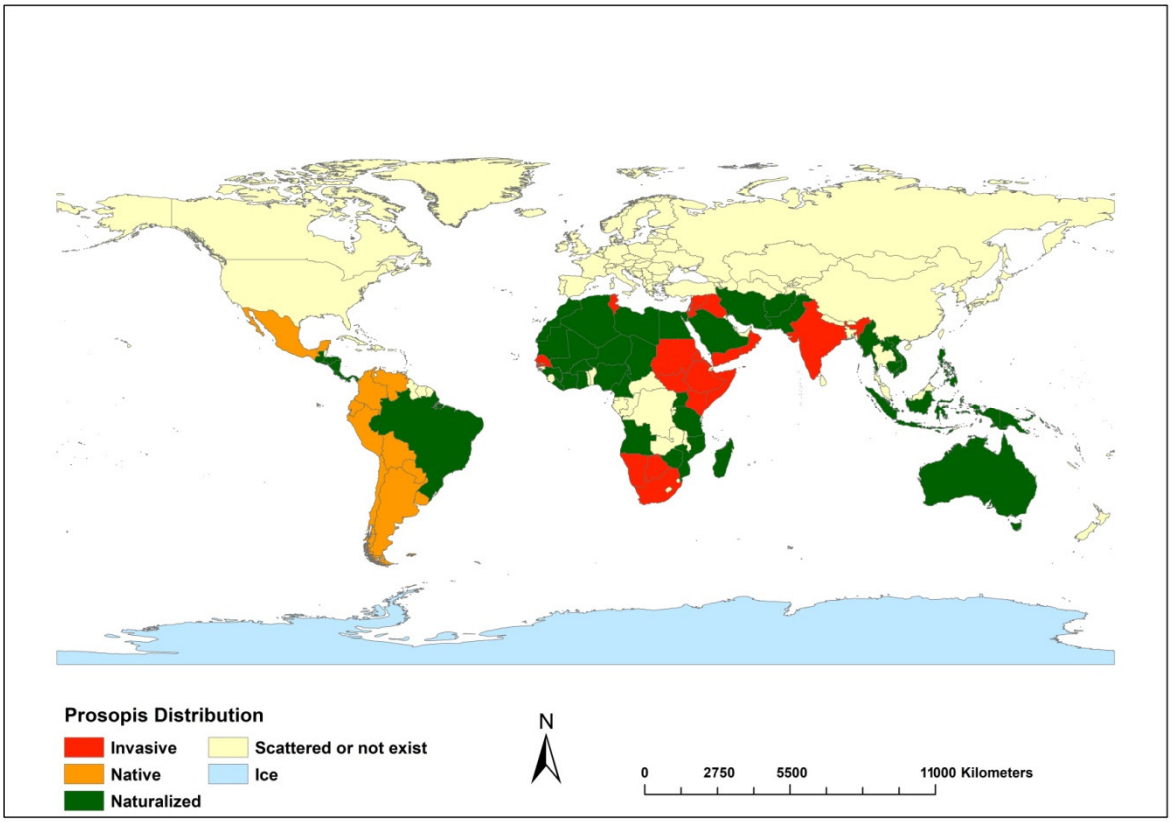

Figure 1. Global distribution of *Prosopis* species. Choropleth map is showings *Prosopis* spp. native range, naturalized habitat and the areas facing the risk of invasion [30,38].

In Jordan, *P. juliflora*, one of the highly invasive IPS, is dominantly present in the Dead Sea region and continues to spread into the surrounding region across the Jordan Valley (Figure 2) [39]. In the period between 1950 and 1980, *P. juliflora* (locally known as *Al-Salm*) was introduced by Ministry of Agriculture along with other tree species into Sweimeh with the aim of afforestation [28]. The introduction of *Prosopis* was justified due to the fact of its ability to tolerate biotic (diseases) and abiotic (drought and high temperatures) stresses [28].

Within the above context, the objectives of this research were to assess the socio-economic impacts of *P. juliflora* invasion on the ecosystems in Sweimeh village in the Dead Sea area of Jordan Valley and to explore community preferences for *P. juliflora* management plans. To achieve these objectives, the following questions were addressed: what are the households' perceptions of the impact of the *P. juliflora* invasion on ES? What are the estimated economic benefits and costs of the *P. juliflora* invasion for the livelihood of local families living at the study site? What is the most acceptable management plan based on the knowledge of *P. juliflora* invasions for the local community based on the knowledge of *P. juliflora* invasions in the study area?

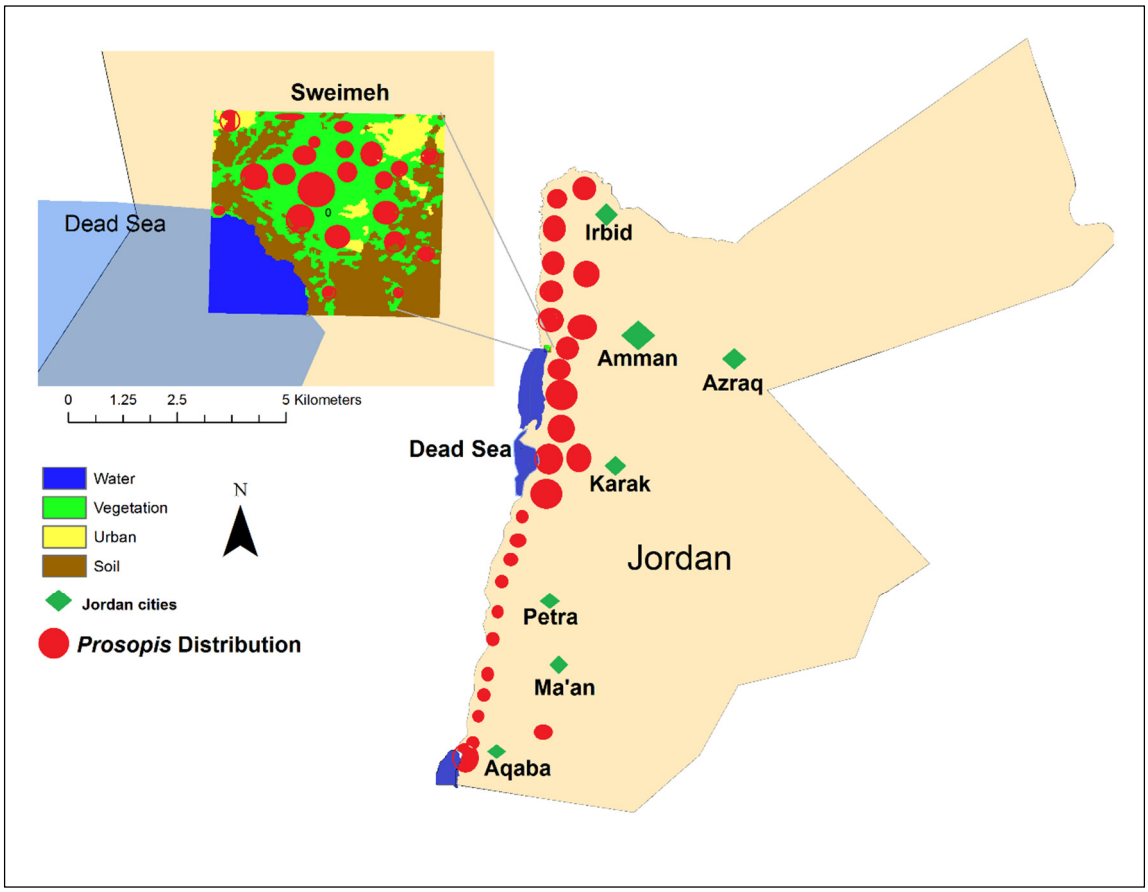

Figure 2. *Prosopis juliflora* distribution in Jordan including the study area Sweimeh village in the Dead Sea area, Jordan [28,39].

2. Materials and Methods

2.1. Study Area

The Sweimeh village was selected for study on the basis of having the most severe invasion of *P. juliflora* in the Jordan Valley [28]. The Sweimeh village occupies 340 ha and is located 74 km to the southwest of the capital Amman (Figure 2).). The village is located within the Jordan Valley; it has hot, dry summers with an average temperature of 40 °C. The location has mild winters with a 10-year mean temperature of 11 °C for the coldest month and 40 °C for the warmest month, and an average annual precipitation of 100 mm [40].

Sweimeh village is classified as being among the poorest areas in Jordan with a lack of basic infrastructure and job opportunities. In the last decade, the farming systems have slowed down with limited options for other economic activities outside of tourism. The population of Sweimeh village is around 5000 individuals, within 726 households [41]. The main economic activities in Sweimeh include agriculture and micro projects of trading and tourism. The level of employment is low. Many households depend on seasonal work opportunities in tourism and governmental social support. ArcMap (Version 10.2 for Windows; ESRI, Redlands, CA, USA) was used to generate the study map. Shape files for Sweimeh and Jordan are provided free of charges by Ministry of Agriculture, Jordan.

2.2. Study Sample

The study used a mix of household surveys, focus groups and discussions with key persons at the study area. Two focus groups meetings, with 15–20 community members for about 90–120 min, were conducted. The discussion subjects in the focus group were to identify and rank the services

and disservices of *P. juliflora* invasion the area, assign roles for different stakeholders in *P. juliflora* management, and designate the responsibility for all stakeholders of *P. juliflora* invasion in the area.

Based on Department of Statistics population's census in 2015, household surveys were conducted with 203 randomly selected households, which represent 28% of the total households. Structured interviews were then administered to individuals from the households and were selected to ensure representation of different gender, age, occupation and wealth categories. The head of the household or the wife was interviewed for about 45 min. The data collection started from August till November of 2018. The questionnaires were answered based on face-to-face interviews with the written consent of the respondent to participate in the field study, based on the ethical approval granted by the University of Jordan to conduct the study according to the general university regulations.

Key informants were engaged throughout the focus group meetings and household surveys, providing information on previous and current projects implemented in this study area. Such projects aimed to encourage ecotourism, sustain the agricultural ecosystem and highlight the official efforts to maintain a safe environment for the local community. The key informants included the staff of governmental institutions in the area, working non-governmental organizations (NGOs) and conservation practitioners and researchers.

2.3. Study Instruments for Data Collection

A structured questionnaire was designed, pre-tested, and validated targeting the local community in the study area. The structure and content of the questionnaire were based on the information gathered from the focus group sessions. The questionnaire included six parts; the first part of the questionnaire covered the demographic information of the respondents: gender, age, education level, job, residency period in the area, family size and income. The second part focused on the respondents' relations with the surrounding environment: how *P. juliflora* contributed to vegetation cover, touristic activities, number of visitors to this area and household dependency on tourism. The third part of the questionnaire assessed the impact of *P. juliflora* on agricultural activities with respect to changes in soil, water sources and the reduction of crop production.

In the fourth part, respondents identified and evaluated the effect and importance of *P. juliflora* on ES (e.g., cultural services such as hiking, excursions and camping, provision services such as fodder, fuel wood and charcoal and regulating services such as soil fixing). In the following, fifth part, the respondents were asked to assess the impact of *P. juliflora* on biodiversity, tourism and agricultural and economic activities and on protecting soil from erosion and desertification at the district level. In the last part of the questionnaire, the respondents were asked to choose the management plan that he/she thought would benefit their livelihood: either a plan includes the extensive trimming of *P. juliflora* or other supporting eradication of the *P. juliflora* in the area.

2.4. Data Analysis

The benefits of *P. julifora* were estimated from individuals' replies to direct questions about the quantities of services and products provided by *P. juliflora*, regardless of whether these products were for trading or domestic use. The quantity and types of potential services and products rendered by *P. juliflora* were also informed by extant research. Two other studies [39,42], measured the average production of pods, charcoal, and firewood based on experiments and field estimations of 20-year-old trees, with an invasion level measured at 545 tree/ha, calculating that the average fodder production of a 20-year-old tree was about 0.15 ton/year [39]. The estimated average production of good quality charcoal was about 0.125 ton [43] that is then used for domestic consumption and trading.

The value of the direct benefits derived from *P. juliflora* product usage was determined, in Jordanian Dinar (JOD, USD 1 = JOD 0.71), by multiplying the amount of *P. juliflora* products consumed per household based on the data gathered from household interview as well as the local price for each product. The value of family labor for collecting *P. juliflora* products was not deducted due to the very

low opportunity costs of agricultural work in a region with a high unemployment rate. The consumption of other *P. juliflora* products was associated with negligible cost of labor and transportation.

The value of direct costs of *P. juliflora* was estimated in JOD for direct losses associated with the *P. juliflora* invasion and the amount paid to prevent, repair or treat disservices related to the presence of *P. juliflora*. The estimation process considered the frequency of disservices' occurrence and associated costs for reducing or averting disservices at household levels. The benefit–cost estimations considered the percentage of households that responded for each type of service and disserve, and the comparison was performed at household level.

In terms of the analytical approach, binary logistic regression was selected as it is a model commonly used to explore the decisions between alternatives [44,45]. This model predicts the probability that a respondent with certain characteristics and perceptions will choose a given management plan. This approach is used to study the factors influencing respondents' preferences with respect to different plans to manage the *P. juliflora* invasion in the study area. The model is used to study the choices between two options and predicts the probability that, given certain socioeconomic and demographic determinants, an individual will choose any of the given options. Respondents are expected to make a decision based on the utility level perceived from proposed IAS management plans. In other words, respondents prefer the on-site management plan so long as he or she perceives that the services from the *P. juliflora* invasion outweigh the disservices and thus contribute to better living standards. Otherwise, if the respondent perceives the disservices of the *P. juliflora* invasion as more costly, they are expected to choose the eradication of *P. juliflora*. The respondents were asked to choose either the first plan—the on-site management plan (coded as 1)—which refers to intensive trimming to reduce the negative effects of the invasion, or the second plan (coded as 0), which refers to the complete eradication of *P. juliflora*.

3. Results

3.1. Perceptions of P. Juliflora Invasion

All respondents recognized *P. juliflora* by sight and expressed an ability to identify it in the surrounding environment, referring to it by its local Arabic name *al-Salam*. The majority (97%) of the respondents stated that the propagation of *P. juliflora* had increased over the last 22 years. They attributed this to its particular ability to produce abundant seeds which are spread by the wind and livestock rooming.

During the household survey, the respondents exhibited mixed sentiments about *P. julifora*. Some respondents wanted it removed, especially where it invaded fields or grew in close proximity to their houses. Over 98% of households stated that the invasion of *P. juliflora* has affected agricultural lands and related activities, with 75% of respondents pointing to a severe water shortage caused by the invasion as an example (Table 1). However, 77% of the respondents welcomed it as a source of goods, especially for firewood and fodder production, and indicated the role of *P. juliflora* in enhancing vegetation cover. Most of the responses about the impact of the *P. juliflora* invasion on ES referenced the notable impact the tree has had in enhancing the vegetation cover and the production of firewood and charcoal. It is worth mentioning that most of the lands experiencing a *P. juliflora* invasion were not subjected to the continuous control measures typically used to respond to IAS. This is because the Jordanian Ministry of Agriculture has classified *P. juliflora* as a forestry tree, thereby prohibiting the implementation of any kind of structured, massive or regular management as trimming or/and cutting.

The majority of the respondents used *P. juliflora* for firewood, charcoal production, fodder production and recreation (Table 1). Respondents also pointed out a range of negative impacts or ecosystem disservices connected to *P. juliflora* that lead to reduced human wellbeing. Among these, they report that the invasion has further reduced the availability of freshwater, encroached on the land suitable for grazing, and limited opportunities for educational excursion in the study area. Moreover, the *P. juliflora* invasion has caused direct harm to both human and livestock: the sharp and strong

thorns cause deep injuries for human and livestock, especially for old people, students and for those with preexisting conditions such as diabetes which slow healing.

Table 1. Identified the important ecosystem services and the direction of change in the last decay.

Ecosystem Services (ESs)	Number of Respondents (n = 203)	Importance of ESs	
	R *	Degree **	% of the R
Recreation	110	Important	61%
Educational excursion	48	Not important	50%
Camping	17	Not important	57%
Firewood	171	Important	51%
Charcoal production	156	Important	42%
Animal fodder	172	Very important	47%

* Number of respondents reported ESs. ** Degree of importance: not important at all, not important, important, and very important.

The focus groups pointed out that the invasive *P. juliflora* has dominated the southern region of Dead Sea, displacing useful and native plant communities and affecting the unique flora and fauna ecosystems. As such, respondents were asked to assess the environmental effects of *P. juliflora* invasion at the district level in accordance with a predetermined range of possible impacts (Figure 3). The responses reflected the perceived negative impact of the *P. juliflora* invasion on the local environment as 74% of respondents identified the degree of impact on the local community to be "very bad". Comparatively, only 41% of the respondents identified the impact of *P. juliflora* on the tourism activities as "bad", especially for causing injuries. This reflects the general economic status and the agricultural activities in the region that have been badly affected. Other points of view shed light on the positive effects of *P. juliflora* as it enhances natural vegetation cover, improves soil content and reduces soil erosion.

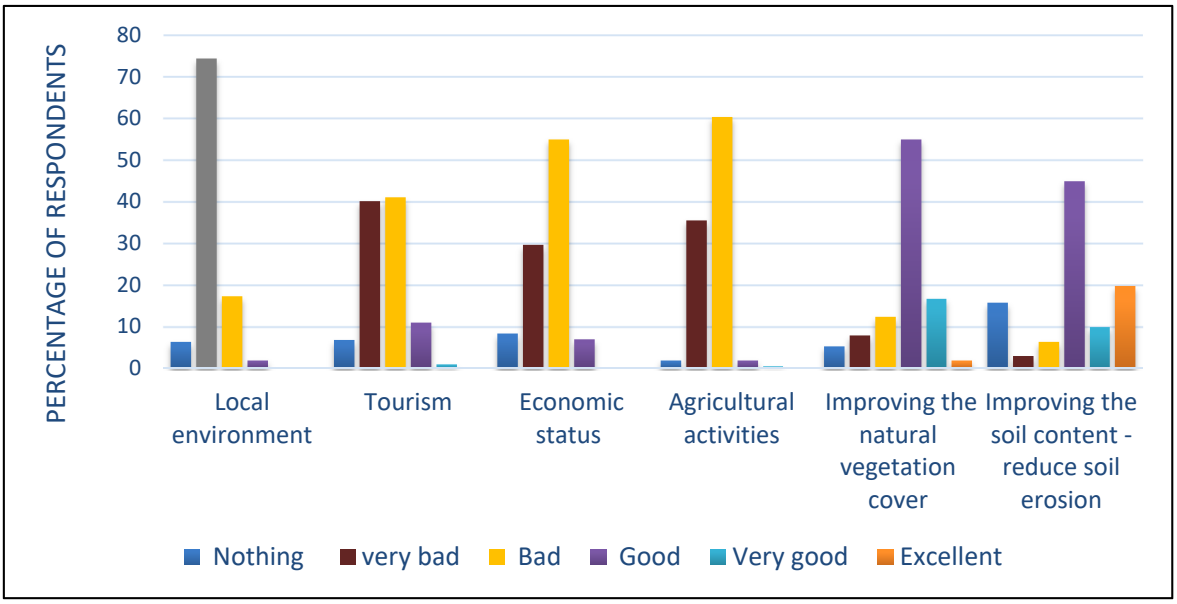

Figure 3. Respondents' perception on the degree of *P. juliflora* impact on the surrounding environment and outside activities in the study area.

3.2. Economic Assessment of the P. Juliflora Invasion Impacts on the Livelihood

3.2.1. Benefits of Prosopis Juliflora Invasion

The benefits were categorized as ecosystem services received from the *P. juliflora* invasion, which was then further divided into two classes of direct and indirect benefits. Direct benefits include the returns and the use values of firewood, charcoal, and fodder for animals. Indirect benefits are the gains for having *P.juliflora* in the surrounding environment, which would mainly be based on non-use values such as the services of household sewage intake and improving tourism services.

The majority of the households used *P. juliflora* for firewood, fodder, and charcoal production, besides other indirect uses such as tourism and sewage intake (Table 2). Every household stated that they use or had used *P. juliflora* for fodder supplies for livestock herds during every season. Though the dependency ratio differs between households; the fodder made of *P. juliflora* pods is 20% cheaper than the monthly cost of purchasing, making it an attractive option to households. The firewood consumption was about 1.4 ton per year, where every household exhibited a different level of dependency on firewood for heating and cooking.

Table 2. Summary of direct and indirect benefits of *P. juliflora* in the study site.

Services	**Average Consumed Quantity (Ton/year)**	**Average Produced Quantity (Ton/ha)**	**Market Price (JOD)**	**Monthly Benefits (JOD)**	**Total Benefits (year)**
Direct benefits					
Pods *	0.15	81.75	-	39	468
Firewood **	1.4	272.5	180	252	252
Charcoal ***	0.125	68.125	150	18.75	56.25
Indirect benefits					
Services	Frequency		Market price (JOD)	Monthly benefits (JOD)	Total benefits (year)
Intake of household sewage	6 times/year		20	10	120
Enhancing tourism ****	Monthly (8 months)		-	160	1280
Estimated total return				489.75	2167.25

* Returns of pods based on the savings from the monthly fodder costs as 20%; the pods are collected by individuals. ** the average production of firewood was about 0.5 ton/tree in a year. *** Charcoal production is estimated to be 48% of the amount of firewood produced (source: (1) from the survey results, and (2) from: [43]). The charcoal is consumed in winter season (3 months). **** Income from tourism calculated from survey results. JOD 1 = USD 0.71.

According to the respondents, *P. juliflora* delivers genuine livelihood assets in the form of job creation, income generation and increased financial capital wherein locals may utilize the shade and the tree structure of *P. juliflora* to open local cafes and restaurants for tourists visiting the Dead Sea. Besides, *P. juliflora* also provides other direct benefits for the households through its ability to consume water from sewage in ground tanks in the yards of homes, which saved households from incurring significant costs to empty the sewage ground tanks every month. Accordingly, the expected benefit from the *P. juliflora* invasion is estimated to be 2167.25 JOD/year considering the utilization levels throughout the year by an average household.

3.2.2. Costs of *P. Juliflora* Invasion

The most commonly reported negative impacts are the loss of agricultural land and the corresponding loss of crops that used to be planted in the area (Table 3), the loss of grazing land and livestock production, the limitations imposed on human mobility and transportation, and the threats to the health and safety of humans. The greatest loss was associated with the loss of natural resources of water and land in this region due to the additional water consumption by *P. juliflora*. The average loss of the agricultural production of 1.72 ha of land was estimated at JOD 1259. A significant shortage in irrigation water also prompted most of the families to stop farming and to reduce the number of livestock they tended (Table 3).

Table 3. The total annual costs of *P. juliflora*'s invasion in the study area according to respondents' responses.

Disservices	Quantity (±SD *)	Cost (JOD/unit)	Total Cost (JOD)
Direct costs			
Human injuries	2 persons (±1.1)	33.3	66.6
Livestock' injuries	4.2 head (±4.7)	5.3	22.26
Disable vehicle's tires	12.9 days (±4.04)	1.9	22.99
Indirect costs			
Reduction in the agricultural land (previous land size)	17.2 du (±30.5)	-	1259.7
Reduction in the grazing area	20% added costs to fodder	39	39
Total costs			1410.55

* SD: standard deviation. JOD 1 = USD 0.71.

Other costs included human and livestock injuries, and damages to vehicle tires due to the sharp and strong thorns. The direct costs associated with these disservices were derived from the actual cost paid for the human and livestock injuries treatments and vehicle maintenance. The financial costs varied through the direct and indirect disservices identified by the local community, it turned out that the annual average cost of the *P. juliflora* invasion was about JOD 1410.5 per household.

Thus, the invasion of *P. juliflora* in Sweimeh provided substantial benefits along with other serious costs (Tables 2 and 3). That said, the *P. juliflora* invasion has positive gross margins in its effects on the sustainability of livelihood strategies through its utilization throughout the year.

Factors influencing community preferences for *P. juliflora* management.

The sample surveyed was similar to the demography of the population living in the southern area of the Dead Sea: the households' heads were mostly retirement-age males, but a greater proportion had at least a middle school education and experienced higher unemployment rates. Only 26.6% of them were previously farmers who had stopped farming and the average residency period in this village was about 35.6 years. This village is recognized as one of the poverty pockets in Jordan, where the average family monthly income is about JOD 418.31—well under the official poverty line of JOD 814 [46].

The study site was undergoing several consecutive operations allowed by high ranking officials to manage the *P. juliflora* invasion on street sides, school areas, and other public facilities, with one such operation underway at the time of the study. This situation helped in balancing the pros and cons of the *P. juliflora* invasion that were identified by the different respondents. However, only 34.5% of the respondents supported the management option versus 65.5% of the respondents demanding for complete eradication. To this end, respondents suggested various procedures, either severe trimming

or mechanical uprooting—especially for clearing the agricultural land—or burning the tree to produce charcoal for local consumption. However, other respondents supported the option of managing the *P. juliflora* invasion by maintaining the distance between the tree and certain areas or controlling the growth by regular trimming of the trees, thus providing an additional income through constant provisioning of firewood and charcoal.

The logistic regression model revealed the relationship between the factors influencing respondents' preferences for the different management plans for the *P. juliflora* invasion at this site. The regression model was used to explore the variables that were suggested by other researchers as possible influences on public preferences for IAS management [47,48]. Most of these variables (education level, job types, residency period, and family size) were not significant and the AIC (Akaike information criterion) for the initial model was high (AIC = 69.8), and thus were excluded from the analysis. Nonetheless, other socio-economic factors (age, income, and gender), the respondent's personal knowledge and their perception of the impact of the *P. juliflora* invasion on the surrounding ecosystem (*P. juliflora* invasion impacts on: economic situation, agricultural practices, vegetation cover, soil erosion and desertification) were found to be significant and resulted in a robust logistic regression model, as the AIC was dropped to 29.3. The definitions of these variables are presented in Table 4.

Table 4. Variables in binary logistic regression model predicting management preferences of *P. juliflora* invasion in Sweimeh area.

Variables	Definitions	Value	Cronbach's Alpha **
Gender (% male)	Dummy variable: 1 if male, 0 if female	82%	-
Age (% of the sample)	Categorical variable: 1—Age (20–34 years old	9.9	-
	2—Age (35–49 years old)	49.8	
	3—Age (50–64 years old)	36.9	
	4—Age (65–80 years old)	3.4	
Family monthly income (% of the sample)	Categorical variable: 1—level (JOD 150–299 *)	10.2	
	2—level (JOD 300–449)	56.8	
	3—level (JOD 450–599)	21.1	
	4—level (JOD 600–749)	6.8	
	5—level (JOD 750–900)	5.1	
PJ impact—economic situation	PJ impact on the economic situation in Sweimeh village. (Scale, 1 = nothing, to 6 = excellent)		0.733 (No. of items on scale = 6)
PJ impact—agricultural practices	PJ impact on agriculture practices (Scale, 1 = nothing, to 6 = excellent)		
PJ impact—improving the vegetation cover	PJ impact on improving the vegetation cover (Scale, 1 = nothing, to 6 = excellent)		
PJ impact—preventing soil erosion	PJ impact on preventing soil erosion and desertification. Scale, 1 = nothing, to 6 = excellent)		

* JOD 1 = USD 0.71. ** Number of items and Cronbach's alpha only reported for one variable measured with multiple items that was used to measure the consistency of the respondent's perception of the impacts of *P. juliflora* invasion on the surrounding environment. The measures were not combined in a single scale.

The logistic regression model revealed the relationships between the socioeconomic characteristics and perceptions of the local community and the preferences for different *P. juliflora* invasion management plans. As a whole, the model performed well ($p < 0.01$) as indicated by the high value of the Omnibus test and the lower value of log likelihood (Table 5). The goodness of fit test determined if there was a significant relationship between the tested factors and the preferred management plan for the *P. juliflora* invasion. The percentage of correct prediction is high at about 71.4%, which means the explanatory variables are capable of accounting for 71.4% of the variation in respondents' preferences for different management plans of *P. juliflora* invasion. All explanatory variables included in the logistic regression contributed well to building a final model reflecting public perceptions of *P. juliflora* invasion management. It is also surprising that in the model, gender, age and perceptions of the invasion's impacts on the economic situation, agricultural practices and vegetation cover did not have a statistically significant relationship with the choice of plan.

Table 5. Parameter estimation from the binomial logistic regression model predicting the management preferences of *P. juliflora* invasion.

Variables	B	S.E	Wald	Sig.	Exp (B)
Gender (male)	0.396	0.522	0.577	0.447	0.673
Age (20–34 years old)	−1.414	1.176	1.445	0.229	0.243
Age (35–49 years old)	−0.997	1.068	0.871	0.351	0.369
Age (50–64 years old)	−1.288	1.035	1.548	0.213	0.276
Family monthly income (150–299 JOD)	0.036	0.859	0.002	0.967	1.036
Family monthly income (300–449 JOD)	1.255	0.424	8.772	0.003 **	3.509
Family monthly income (450–599 JOD)	1.776	0.585	9.203	0.002 **	5.905
Family monthly income (600–749 JOD)	2.396	0.940	6.495	0.011 *	10.984
Family monthly income (750–900 JOD)	1.378	0.938	2.158	0.142	3.967
PJ impact on the economic situation (nothing)	0.242	1.168	0.043	0.836	1.274
PJ impact on the economic situation (very bad)	−0.322	0.644	0.250	0.617	0.724
PJ impact on the economic situation (bad)	−0.092	0.546	0.028	0.866	0.912
PJ impact on agricultural practices (nothing)	0.321	0.498	0.416	0.519	1.379
PJ impact on improving the vegetation cover (nothing)	0.996	0.563	3.128	0.077 ***	2.707
PJ impact on preventing soil erosion and desertification (nothing)	1.785	0.749	5.675	0.017 *	5.959
PJ impact on preventing soil erosion and desertification (very bad)	2.664	1.157	5.298	0.021 *	14.351
PJ impact on preventing soil erosion and desertification (bad)	1.604	0.829	3.738	0.053 ***	4.971

Table 5. *Cont.*

Variables	B	S.E	Wald	Sig.	Exp (B)
PJ impact on preventing soil erosion and desertification (good)	1.642	0.602	7.433	0.006 **	5.166
PJ impact on preventing soil erosion and desertification (very good)	1.769	0.759	5.435	0.020 *	5.865

* Significant at 5% level. ** Significant at 1% level. *** Significant at 10% level. 2 Log likelihood = 211.441, Omnibus test of model coefficients (X^2, df, sig.) = 50.098,19, 0.01 Cox and Snell R^2 = 0.219, Nagelkerke R^2 = 0.302. Percentage of correct predictions = 71.4%. The initial model had AIC (Akaike information criterion) equal to 69.8, while the final model had AIC equal to 29.3.

The results from the logistic regression models showed that the respondents from the middle level of monthly income had good odds to support the management option of *P. juliflora* in their region, as those of income level of JOD 300–449 and 450–599 had positive and significant odds ($p < 0.05$) for supporting the management option as the odds were 3.5 and 5.9, respectively. Those respondents of higher income, JOD 600–749, had significant ($p < 0.05$) and the greatest odds (10.9) to be of a group supporting the management plan.

Moreover, the respondent's perceptions of *P. juliflora* impact on preventing soil erosion and desertification were significant and contributed to explaining the respondent's selection of a *P. juliflora* invasion management plan. Apparently, respondents that supported a *P. juliflora* management plan over eradication had different opinions on the impact of the invasion on soil erosion and desertification ($p < 0.01$, $p < 0.05$, $p < 0.1$). Regardless of the perceived level of impact on soil erosion, those respondents had the highest probability to be one of the households supporting the management plan of *P. juliflora* invasion as the odds ranged between 4.9–14.35 (Table 5).

4. Discussion

Elderly respondents report that *P. juliflora* has been in the study area for at least four decades, which indicates that the invasion has been well-established for some time. Additionally, all respondents and key persons stated that its abundance has increased in the past twenty years and that it is still expanding. This reflects the perceptions of villagers at Sweimeh as stated in the focus groups, where *P. juliflora* was deemed to have increased dramatically over the previous twenty years with a confirmed and clear expansion toward the south of Dead Sea, ultimately reaching Ghor Alsafi [40,43]. Local villagers attributed this to the high quantity of seeds and to livestock's ability to disperse seeds while roaming in the village and surrounding grazing areas [49,50]. The fodder prepared by the locals is mainly leaves and pods for maximum protein content, thus, as the villagers and local experts pointed out, it helped in spreading the seeds and expanding *P. juliflora* invasion in the area. The experts recommended using pods in the ration after seed grinding as much as possible to make sure the seeds are crushed to more than half to decrease the possibility of endozoochoric dissemination when eaten by livestock.

At the same time, many official workers and other active NGOs in the region have illustrated the nature of *P. juliflora* as an alien species introduced to the region, which is tied to national efforts to sensitize people to the impacts of *P. juliflora* invasion. This contradicts the fact that Jordanian law considers *P. juliflora* to be a forestry tee, which is protected by law and not allowed to be cut down unless the Minister of Agriculture provides permission in special cases for control operations in specific areas for limited periods as stated by Agriculture law, 13 [51]. This diverges from law in other countries, where it is allowed to be cut down as a method of controlling its spread [32,52]. Since law prohibits *P. juliflora* from being cut down, civil endeavors have managed to secure restricted permissions for intensive trimming under the supervision of the local administration.

Respondents demonstrated remarkable clarity on the value of *P. juliflora* in the local landscapes and were able to report the costs and benefits—both actual and potential benefits and costs—of the *P. juliflora* invasion. The primary benefits were the provision of charcoal, pods for fodder and fuel wood as sources of cheap energy in a remote area. These products directly contributed as income sources (charcoal and fuel wood) and as replacements for expensive animal fodders (pods and leaves) as others have indicated [29,31,52,53]. The results provided the estimated annual income for the household from *P. juliflora* (JOD 2167) considering the scenario in which the current forestry law is modified to allow for legal use.

However, the costs associated with *P. juliflora* in the village and the landscapes were not insubstantial. First, the presence of *P. juliflora* in the regional ecosystem prevents the natural growth of native species, as reported in other regional cases [54,55], though this has not yet been studied in Jordan. Moreover, crops do not grow well in the vicinity of *P. juliflora*, wherein respondents referred to *P. juliflora* as a competitor for irrigation water and soil moisture [56]. The presence of *P. juliflora* in fields leads to significantly lower crop yields, forcing some to stop farming altogether and contributing to the high rate of unemployment in an already poor region. Health hazards were also listed as a cost as *P. juliflora* is able to injure humans and animals, forcing them to seek treatments and take time for recovery. Once *P. juliflora*'s thorns prick, they cause severe inflammation and gangrene, sometimes requiring amputation [32]. *P. juliflora* pollen can cause allergy-induced asthma, rhinitis, and dermal allergic reactions [57]. Overall, the income lost when locals decided to stop farming contributed substantially to the costs incurred by households—costs estimated to be JOD 1410.5 per year.

Results from the cost-benefit analysis revealed that in general, the benefits exceed the costs (losses) of the *P. juliflora* invasion as it currently stands. Thus, either the current invasion level will be maintained or more tightly controlled throughout the area of Swemeh, to the south of Dead Sea. In our study, the higher benefits compared to the costs associated with *P. juliflora* might be due to the relatively short period of *P. juliflora* proliferation. Its introduction and rapid growth and expansion in the past two decades have produced short-term tangible benefits from which respondents have directly and indirectly benefited. This is consistent with the empirical findings of [58] wherein the early years of *P. juliflora's* introduction; it was perceived positively but as it continued to proliferate locals became increasingly less tolerant of its presence.

The management preferences demonstrate attitudes towards management outcomes, effectiveness and methods. The results indicated that a majority of respondents preferred complete eradication (65.5%), yet as previously stated, the cost–benefit analysis showed that the issue is not so straightforward. The increases or reductions in welfare perceived to be related to the *P. juliflora* invasion may not be the same across all ecosystems and the impact of the invasion on individuals within any given community are unlikely to be identical. For example, pastoralists and farmers would be more likely to incur costs as a result of the invasion due to the depletion of lands for grazing and agriculture whiles other community members might depend on *P. juliflora* products for trading and enjoy benefits from the invasion [59]. The econometric model indicated that only respondents' monthly income and their perception of *P. juliflora's* ability to prevent soil erosion and desertification were significant predictors of respondents' preference for *P. juliflora* management plans. Most middle-income households in the region supported the management option. This might be attributed to the fact that *P. juliflora* has had a significant, positive impact on the households' wellbeing as *P. juliflora*'s benefits outweigh its costs (Tables 2 and 3). This is consistent with other studies that have shown income, along with other socio-economic determinants, affects public attitudes towards IAS management [59–62]. Moreover, the household's concern for soil erosion and desertification affected their attitudes towards IAS management. Locals surprisingly noticed the subtle impacts of *P. juliflora* on the soil structure and vegetation patterns, as *P. juliflora* has had a significant impact on soil development and reforestation projects [63], has exhibited an ability to preserve soil moisture and has built and increased the nutrient pool in the soil structure [64].

With such a complex and dynamic situation, in terms of the invasion status of *P. juliflora*, economic determinants of locals (dependency on direct benefits, foreseeable costs, and living in a remote area with low employment rate) and recent emerging institutional responses (governmental and civilian), it is difficult to predict what the future might hold for this ecosystem and the local community. The ecological studies indicate that the invasion of *P. juliflora* is likely to spatially expand and proliferate throughout the region, certainly in the short to medium term. Therefore, there needs to be a push for more co-operative management of *P. juliflora* that engages relevant stakeholders [4,24].

5. Conclusions

This study has revealed the dualistic impact of *P. juliflora* on the livelihoods of rural people living in the Sweimeh area to the south of the Dead Sea. On one hand, the use of *P. juliflora* products for several livelihood needs is common and represents a significant opportunity for households—most of whom are poor by the national measures—to generate additional income and save. On the other hand, the growing presence of *P. juliflora* increases local households' vulnerability through the reported reductions in areas for cultivation, crop yields, and grazing land, and health hazards.

This dilemma is further complicated by the fact that a considerable majority of respondents and official workers not only do not want the presence of *P. juliflora* to increase, but many demand its total removal from the landscape. Others, still, would like it to be maintained, probably in areas spatially separated from homesteads, tourism sites, fields, and access routes where the disadvantages are less tangible. Officials' and local NGOs' efforts currently focus on *P. juliflora's* regular removal from internal routes, schools and spaces in proximity to homesteads. More coordinated responses between institutions and communities are needed if the *P. juliflora* invasion is to be controlled in more communal areas such as the touristic sites, routes, and rangelands. Therefore, the legal framework governing the forestry sector in Jordan needs to be revised and modified, and the restrictions on utilizing this tree must be eliminated. The costs associated with losing agricultural land are huge.

Although this study has shown the situation to be complex, understanding perceptions and uses of *P. juliflora* can help environmental policy makers formulate response strategies. First, whilst the use of *P. juliflora* is widespread, its potential benefits are not fully utilized as rural communities often opt to use alternative, legal sources of energy over those derived from *P. juliflora*. Thus, the entire *P. juliflora* stock found in the local environment will not be used for firewood or its other derivatives. This suggests that any control efforts should, in the short term, seek to limit the current invasion and prepare and execute a national IAS strategy for eradication in the long term. Second, additional efforts are needed from ecologists and local communities to determine on which sections of the landscape local communities would be amenable to *P. juliflora* growth and where they explicitly prefer its removal. This will facilitate collaboration, allow for spatial prioritization of control efforts and aid in the propagation and planting of native, alternative species suited to the ecosystem.

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References

1. Marchante, H.; Marchante, E.; Freitas, H.; Hoffmann, J.H. Temporal changes in the impacts on plant communities of an invasive alien tree, Acacia longifolia. *Plant Ecol.* **2015**, *216*, 1481–1498. [CrossRef]
2. Gallardo, B.; Clavero, M.; Sánchez, M.I.; Vilà, M. Global ecological impacts of invasive species in aquatic ecosystems. *Glob. Chang. Biol.* **2015**, *22*, 151–163. [CrossRef] [PubMed]
3. Walsh, J.R.; Carpenter, S.R.; Zanden, M.J.V. Invasive species triggers a massive loss of ecosystem services through a trophic cascade. *Proc. Natl. Acad. Sci. USA* **2016**, *113*, 4081–4085. [CrossRef]
4. Shackleton, R.T.; Shackleton, C.M.; Kull, C.A. The role of invasive alien species in shaping local livelihoods and human well-being: a review. *J. Environ. Manag.* **2019**, *229*, 145–157. [CrossRef] [PubMed]
5. [CBD] Convention on Biological Diversity: What are Invasive Alien Species. Available online: https://www.cbd.int/invasive/WhatareIAS.shtml#targetText=Invasive%20alien%20species%20(IAS)%20are,present%20distribution%20threatens%20biological%20diversity.&targetText=A%20species%20introduction%20is%20usually%20vectored%20by%20human%20transportation%20and%20trade (accessed on 6 May 2020).
6. [NWF] the National Wildlife Federation: Invasive Species. Available online: https://www.nwf.org/Educational-Resources/Wildlife-Guide/Threats-to-Wildlife/Invasive-Species (accessed on 6 May 2020).
7. Novoa, A.; Kaplan, H.; Wilson, J.R.; Richardson, D.M. Resolving a prickly situation: Involving stakeholders in invasive cactus management in South Africa. *Environ. Manag.* **2016**, *57*, 998–1008. [CrossRef]
8. Hoffmann, B.D.; Broadhurst, L.M. The economic cost of managing invasive species in Australia. *NeoBiota* **2016**, *31*, 1–18. [CrossRef]
9. van Wilgen, B.W.; Fill, J.M.; Govender, M.; Foxcroft, L.C. An assessment of the evolution, costs and effectiveness of alien plant control operation in Kruger National Park, South Africa. *NeoBiota* **2017**, *35*, 35–59. [CrossRef]
10. Kiehn, M. Plant introductions: Historical sketches. *Pac. Sci.* **2012**, *66*, 119–125. [CrossRef]
11. Prinbeck, G.; Lach, D.; Chan, S. Exploring stakeholders' attitudes and beliefs regarding behaviors that prevent the spread of invasive species. *Environ. Educ. Res.* **2011**, *17*, 341–352. [CrossRef]
12. Donlan, C.J.; Wilcox, C. Complexities of costing eradications. *Anim. Conserv.* **2007**, *10*, 154–156. [CrossRef]
13. Bauer, J.T. Invasive species: "back-seat drivers" of ecosystem change? *Biol. Invasions* **2012**, *14*, 1295–1304. [CrossRef]
14. Shackleton, S.E.; Kirby, D.; Gambiza, J. Invasive plants—Friends or foes? Contribution of prickly pear (Opuntia ficus-indica) to livelihoods in Makana Municipality, Eastern Cape, South Africa. *Dev. S. Afr.* **2011**, *28*, 177–193. [CrossRef]
15. Thomas, C.D.; Moore, N. *Invasive Species—Friends or Foes*; the Royal Society of Edinburgh: Edinburgh, UK, 2014.
16. Shackleton, R.T.; Le Maitre, D.C.; Richardson, D.M. Stakeholder perceptions and practices regarding Prosopis (mesquite) invasions and management in South Africa. *Ambio* **2015**, *44*, 569–581. [CrossRef] [PubMed]
17. van Wilgen, B.W.; Richardson, D.M. Challenges and trade-offs in the management of invasive alien trees. *Biol. Invasions* **2014**, *16*, 721–734. [CrossRef]
18. Shackleton, R.T.; Witt, A.B.R.; Piroris, F.M.; van Wilgen, B.W. Distribution and socio-ecological impacts of the invasive alien cactus Opunita stricta in eastern Africa. *Biol. Invasions* **2017**, *19*, 2427–2441. [CrossRef]
19. Kannan, R.; Shackleton, C.M.; Shaanker, R.U. Invasive alien species as drivers in socio-ecological systems: Local adaptions towards use of Lantana in Southern India. *Environ. Dev. Sustain.* **2014**, *16*, 649–669. [CrossRef]
20. Lindemann-Matthies, P. Beasts or beauties? Laypersons' perception of invasive alien plant species in Switzerland and attitudes towards their management. *NeoBiota* **2016**, *19*, 15–33. [CrossRef]
21. Cáceres-Escobar, H.; Davis, K.J.; Atkinson, S.C.; Possingham, H.P.; Kark, S. Integrating local social-ecological knowledge to prioritise invasive species management. *PeerJ Prepr.* **2018**, *6*, e27113v1.
22. Howard, P.L. Human adaptation to invasive species: a conceptual framework based on a case study metasynthesis. *Ambio* **2019**, *48*, 1401–1430. [CrossRef]
23. Shackleton, C.M.; Ruwanza, S.; Sinasson Sanni, G.K.; Bennet, S.; De Lacy, P.; Modipa, R.; Mtati, N.; Sachikonye, M.; Thondhlana, G. Unpacking Pandora's Box: Understanding and categorising ecosystem disservices for environmental management and human wellbeing. *Ecosystems* **2016**, *19*, 587–600. [CrossRef]

24. Ngorima, A.; Shackleton, C.M. Livelihood benefits and costs of an invasive alien tree (Acacia dealbata) to rural communities in the Eastern cape, South Africa. *J. Environ. Manag.* **2019**, *229*, 158–165. [CrossRef] [PubMed]
25. Semenya, S.S.; Tshisikhawe, M.P.; Potgieter, M.T. Invasive alien plant species: a case study of their use in the Thulamela Local Municipality, Limpopo Province, South Africa. *Sci. Res. Essays* **2012**, *7*, 2363–2369.
26. Mbambala, S.G.; Tshisikhawe, M.P.; Masevhe, N.A. Invasive alien plants used in the treatment of HIV/AIDS-related symptoms by traditional healers of Vhembe municipality, Limpopo Province, South Africa. *Afr. J. Tradit. Complementary Altern. Med.* **2017**, *14*, 80–88. [CrossRef]
27. Wakie, T.T.; Laituri, M.; Evangelista, P.H. Assessing the distribution and impacts of *Prosopis juliflora* through participatory approaches. *Appl. Geogr.* **2016**, *66*, 132–143. [CrossRef]
28. Tadros, M.J.; Al-Assaf, A.; Othman, Y.A.; Makhamreh, Z.; Taifour, H. Evaluating the Effect of *Prosopis juliflora*, an Alien Invasive Species, on Land Cover Change Using Remote Sensing Approach. *Sustainability* **2020**, *12*, 5887. [CrossRef]
29. Walter, K.J.; Armstrong, K.V. Benefits, threats and potential of Prosopisin South India. *For. Trees Livelihoods* **2014**, *23*, 232–247. [CrossRef]
30. Shackleton, R.T.; Le Maitre, D.C.; Pasiecznik, N.M.; Richardson, D.M. Prosopis: a global assessment of the biogeography, benefits, impacts and management of one of the world's worst woody invasive plant taxa. *AoB Plants* **2014**, *6*, plu027. [CrossRef] [PubMed]
31. Hintsa, K.; Balehegn, M.; Birhane, E. *Livestock Research for Rural Development: Utilization of Pods of Prosopis Juliflora, an Invasive Tree, as a Replacement to Concentrate Feed for Goats in Ethiopia*; Fundación CIPAV: Cali, Colombia, 2015; ISSN 0121-3784.
32. Daniels, S.; DeLyser, D.; Entrikin, J.N.; Richardson, D. Still-Life, After-Life and the Demands of Landscape. In *Envisioning Landscapes, Making Worlds: Geography and the Humanities*, 1st ed.; Sebald, W.G., Dubow, J., Eds.; Routledge: London, UK, 2011; Chapter 18.
33. Meier, E. *WOOD! Identifying and Using Hundreds of Woods Worldwide*, 1st ed.; the Wood Database: Hopkins, MN, USA, 2015.
34. Chandrasekaran, S.; Saraswathy, K.; Saravanan, S.; Kamaladhasan, N.; Nagendran, N.A. Impact of Prosopis juliflora on nesting success of breeding wetland birds at Vettangudi bird sanctuary, South India. *Curr. Sci.* **2014**, *106*, 676–678.
35. Silva, V.D.A.; Pitanga, B.P.S.; Nascimento, R.P.; Souza, C.S.; Coelho, P.L.C.; Menezes-Filho, N.; Silva, A.M.M.; Costa, M.D.; El-Bachá, R.S.; Velozo, E.S.; et al. Juliprosopine and Juliprosine from Prosopis juliflora Leaves Induce Mitochondrial Damage and Cytoplasmic Vacuolation on Cocultured Glial Cells and Neurons. *Chem. Res. Toxicol.* **2013**, *26*, 1810–1820. [CrossRef]
36. Rembold, F.; Leonardi, U.; Ng, W.T.; Gadain, H.; Meroni, M.; Atzberger, C. Mapping areas invaded by Prosopis juliflora in Somaliland on Landsat 8 imagery. In Proceedings of the SPIE REMOTE SENSING, Toulouse, France, 21–24 September 2015.
37. Gunarathne, U.K.; Perera, A. Does the invasion of Prosopis juliflora cause the die-back of the native Manilkara hexandra in seasonally dry tropical forests of Sri Lanka? *Trop. Ecol.* **2016**, *57*, 475–488.
38. Edrisi, S.A.; El-Keblawy, A.; Abhilash, P.C. Sustainability Analysis of *Prosopis juliflora* (Sw.) DC Based Restoration of Degraded Land in North India. *Land* **2020**, *9*, 59. [CrossRef]
39. Abulaila, K. *The Black Book of Invasive Alien Plant Species of Jordan*, 1st ed.; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ): Bonn, Germany, 2019; pp. 4–20.
40. Zaitoun, S.; Al-Ghzawi, A.A.M.; Samarah, N.H. Distance from honeybee colonies and raceme order affect Prosopis juliflora (Sw.) DC. Flower pollination and seed set. *Adv. Hortic. Sci.* **2009**, *59*, 349–356.
41. [DoS] Department of Statistics: General Population and Housing. 2015. Available online: http://dosweb.dos.gov.jo/wp-content/uploads/2017/08/Census2015_Eng.pdf (accessed on 6 May 2020).
42. Tadros, M. *Prosopis Eradication in Swemeh*; Royal: Amman, Jordan, 2012.
43. Kumar, R.; Chandrashekar, N. Study on fuelwood and carbonization characteristics of Prosopis juliflora. *J. Indian Acad. Wood Sci.* **2016**, *13*, 101–107. [CrossRef]

44. Al-Assaf, A.; Majdalwai, M.; Nawash, N. Factors affecting farmer's decision to continue farm activity in marginal areas of Jordan. *Afr. J. Agric. Res.* **2011**, *6*, 2755–2760.
45. da Costa, P.; Hernandez, D. The Economic Value of Ecosystem Conservation: a Discrete Choice Experiment at the Taravo River Basin in Corsica. *Archives Ouvertes HAL.* **2019**, *hal-01971681*, 1.
46. [DoS] Department of Statistics: Absolute Poverty Line by Governorate and Year. 2010. Available online: http://jorinfo.dos.gov.jo/PXWeb2014R2/Selection.aspx?px_tableid=Table2.px&px_path=Poverty__Poverty%20Indicators&px_language=en&px_db=Poverty&rxid=e0c35eac-d04f-4689-ace3-8f29bf1f19da (accessed on 6 May 2020).
47. Sharp, R.L.; Larson, L.R.; Green, G.T. Factors influencing public preferences for invasive alien species management. *Biol. Conserv.* **2011**, *144*, 2097–2104. [CrossRef]
48. Fischer, A.P.; Charnley, S. Private Forest Owners and Invasive Plants: Risk Perception and Management. *Invasive Plant Sci. Manag.* **2012**, *5*, 375–389. [CrossRef]
49. Morgan, A.; Hamdoun, A.M.; Bashir, N.H.H. Studies on Seed Germination and Seedling Emergence of Mesquite, Prosopis juliflora (Swartz) DC. in Sudan Gezira. *Univers. J. Agric. Res.* **2017**, *5*, 159–163. [CrossRef]
50. Abbas, A.M.; Figueroa, M.E.; Castillo, J.M. Burial effects on seed germination and seedling establishment of Prosopis juliflora (SW.) DC. *Arid Land Res. Manag.* **2019**, *33*, 55–69. [CrossRef]
51. [MOA] Ministry of Agriculture. *Agriculture Law 13*; Ministry of Agriculture: Amman, Jordan, 2015.
52. Walter, K. Prosopis, an Alien among the Sacred Trees of South India. Ph.D. Thesis, University of Helsinki, Helsinki, Finland, 2011.
53. de Oliveira, G.S.; de Souza, E.J.; Véras, A.S.; de Paula, M.; da Cunha, M.V.; Torres, T.R.; da Silva, C.S.; Pereira, G.F. Total replacement of corn by mesquite pod meal considering nutritional value, performance, feeding behavior, nitrogen balance, and microbial protein synthesis of Holstein-Zebu crossbred dairy steers. *Trop. Anim. Health Prod.* **2016**, *48*, 1415–1420. [CrossRef]
54. dos Santos, L.L.; do Nascimento, A.L.; Vieira, F.J.; da Silva, V.A.; Voeks, R.; Albuquerque, U.P. The cultural value of invasive species: a case study from semi–arid north eastern Brazil. *Econ. Bot.* **2014**, *68*, 283–300. [CrossRef]
55. El-Shabasy, A. Study on allelopathic effect of Prosopis juliflora on mineral content of Acacia ehrenbergiana in Farasan Islands, KSA. *J. Med. Plants Stud.* **2017**, *5*, 130–134.
56. Bibi, S.; Abu-Dieyeh, M.H. Allelopathic effects of the invasive Prosopis juliflora (sw) Dc. On seed germination of selected Qatari native plant species. In Proceedings of the Qatar University Life Science Symposium 2016: Biodiversity, Sustainability and Climate Change, with Perspectives from Qatar, Doha, Qatar, 4–5 December 2016.
57. Assarehzadegan, M.A.; Khodadadi, A.; Amini, A.; Shakurnia, A.H.; Marashi, S.S.; Ali-Sadeghi, H.; Zarinhadideh, F.; Sepahi, N. Immunochemical characterization of Prosopis juliflora pollen allergens and evaluation of cross-reactivity pattern with the most allergenic pollens in tropical areas. *Iran J. Allergy Asthma Immunol.* **2015**, *14*, 74–82. [PubMed]
58. Lemma, B.; Mohammed, N. Distribution and socio-economic impacts of Prosopis juliflora in Gamo Gofa, segen area people and South Omo zones, southern Ethiopia. *Int. J. Agric. Sci. Technol.* **2016**, *4*, 19–27. [CrossRef]
59. Bekele, K.; Haji, J.; Legesse, B.; Schaffner, U. Economic impacts of Prosopis spp. invasions on dryland ecosystem services in Ethiopia and Kenya: Evidence from choice experimental data. *J. Arid Environ.* **2018**, *158*, 9–18. [CrossRef]
60. Bravo-Vargas, V.; Garcia, R.A.; Pizarro, C.; Pauchard, A. Do people care about pine invasions? Visitor perceptions and willingness to pay for pine control in a protected area. *J. Environ. Manag.* **2019**, *229*, 57–66. [CrossRef]
61. Drescher, M.; Graham, B.E.; Warriner, G.K.; Rooney, R.C. An investigation of the effects of conservation incentive programs on management of invasive species by private landowners. *Conserv. Sci. Pr.* **2019**, *1*, e56. [CrossRef]
62. Potgieter, L.; Gaertner, M.; O'Farrell, P.J.; Richardson, D.M. Perceptions of impact: Invasive alone plants in the urban environment. *J. Environ. Manag.* **2019**, *229*, 76–87. [CrossRef]

63. Ahirwal, J.; Maiti, S.K.; Reddy, M.S. Development of carbon, nitrogen and phosphate stocks of reclaimed coal mine soil within 8 years after forestation with Prosopis juliflora (Sw.) Dc. *CATENA* **2017**, *156*, 42–50. [CrossRef]
64. Pandey, C.B.; Singh, A.K.; Saha, D.; Mathur, B.K.; Tewari, J.C.; Kumar, M.; Goyal, R.K.; Mathur, M.; Gaur, M.K. Prosopis juliflora (Swartz) DC.: an invasive alien in community grazing lands and its control through utilization in the Indian Thar Desert. *Arid Land Res. Manag.* **2019**, *33*, 427–448. [CrossRef]