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Conservation of Endangered Indigenous Species through Economic Incentives Adaptable to Local Communities

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ABSTRACT

Objective: The cultivation project of *Kelussia odoratissima* in Central Zagros was initiated to promote the sustainable use of rangelands, develop economically viable secondary products, mitigate soil erosion, and support marginal farmers while preserving the habitat of this endangered species.

Method: A total of 85 participants in the Kelussia cultivation project were surveyed to identify the key motivational factors influencing their engagement.

Results: Using a logit regression model in Shazam software, the study found that the most significant factors at the 1% statistical level were the "desire to conduct new experiments" and the "willingness to participate in similar projects." Additionally, factors such as "satisfaction with received assistance," "agricultural experience," "education," "age," "marital status," and "gender (female)" were significant at the 5% level in influencing project acceptance. The highest Weighted Aggregated Elasticity was observed for the "desire to conduct new experiments" variable. A 1% increase in new project opportunities resulted in a 0.93% increase in participation willingness, while female participation increased the probability of engagement by 0.014%.

Conclusions: Given the economic potential of rangelands, it is recommended that future studies examine the socio-economic factors influencing project acceptance to enhance sustainable conservation efforts.

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Introduction

In recent years, leveraging available resources and promoting alternative livelihoods have emerged as crucial strategies for increasing local income and reducing pressure on natural ecosystems. One effective approach is the sustainable utilization of secondary products (Heubach et al., 2011), along with improved harvesting methods that enhance their economic value. This, in turn, alleviates pressure on natural resources while incentivizing local communities to engage in conservation and responsible harvesting practices. However, the long-term sustainability of ecosystems fundamentally depends on maintaining their structural integrity (Raven & Wackernagel, 2020).

Economic incentives play a complex role in conservation efforts. Rode et al. (2015) examined how financial incentives can either undermine ("crowd out") or strengthen ("crowd in") people's intrinsic motivation to conserve biodiversity and ecosystems. Given the increasing global reliance on economic instruments for conservation, it is essential to assess pre-existing motivations and potential shifts in behavioral structures before large-scale implementation. Similarly, Polome (2016) analyzed forest owners' motivations for participating in biodiversity protection programs, finding that adoption rates depended on economic, social, and ethical motives. Notably, economic and ethical incentives demonstrated a significant crowding-out effect, whereas social motivations remained unaffected. Furthermore, participation in one program negatively correlated with engagement in others.

Restoring low-yield rain-fed farms that have been abandoned due to overgrazing or land degradation remains a viable strategy. One potential approach is planting compatible secondary crops that improve soil stability and promote on-farm conservation (Asrat et al., 2010). *Kelussia odoratissima Mozaff.*, commonly known as wild celery, belongs to the Apiaceae family (Mozaffarian, 2003) and is an endemic species in Iran. Traditionally, the Bakhtiari tribes have used this plant for its sedative and culinary properties (Pirbalouti et al., 2012). Its natural habitat is typically found at high elevations (above 2500 meters), where annual precipitation is around 450 mm, temperatures during the growing season remain below 20ºC, and snow cover persists for at least 130 frost days. Wild celery thrives in shallow to deep soils with moderate to fine texture and no salinity (Iravani & Jaberolansar, 2005).

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Fig. The natural habitat of *Kelussia odoratissima* Mozaff. in the Central Zagros

The cultivation of this endangered species presents economic opportunities for local communities while simultaneously contributing to conservation efforts. Harvesters can generate income through various forms of wild celery, including fresh, dried, pickled, and distilled products. Additionally, its foliage serves as an important fodder source, particularly in winter. With its extensive root system and large crown cover, the plant also plays a significant role in preventing soil erosion. Beyond its economic value, *Kelussia odoratissima* contributes to biodiversity, genetic preservation, and ecotourism due to its unique landscape presence.

While previous studies on *Kelussia odoratissima* have largely focused on its chemical composition, conservation efforts remain limited. The primary objective of this research is to analyze the economic incentives that encourage local communities to participate in *Kelussia* cultivation. Identifying key motivational factors is crucial for reducing the risk of extinction and ensuring sustainable management. A growing body of literature suggests that decentralizing decision-making and granting local communities' control over conservation initiatives can yield significant benefits. Local actors tend to possess greater knowledge of resource dynamics, respond more effectively to environmental changes, and have a vested interest in sustainable harvesting practices. Additionally, engaging with cultural traditions and local leaders fosters increased participation and enhances project success by mitigating the risks associated with cultural insensitivity.

This study assumes that local communities play an active role in the conservation of indigenous species. Accordingly, we aim to identify the most influential factors driving community acceptance of conservation projects and explore how economic motivations shape their participation.

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Method

Study Area

This study was conducted in the Central Zagros region of Iran, covering an area of 2,154.5 km², within the coordinates 49°36' to 50°19' E and 32°37' to 33°4' N. This region is among the highest-altitude areas in the country and is characterized by a semi-humid climate with mild summers (Karimi, 1988). The research examined the impact of various factors on project acceptance by assessing changes in one or multiple variables over time (Fig. 2).

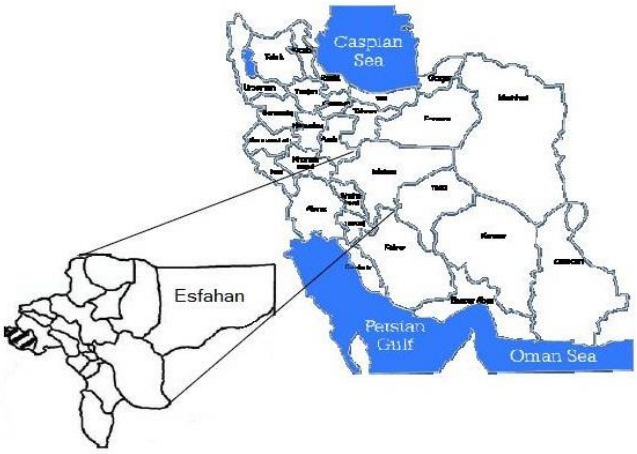

Fig. 2. Study area in Central Zagros, Iran.

Research Methodology

A stratified sampling approach (Binder et al., 2001) was employed to account for the region's climatic, geographical, and cultural differences. The study involved field assessments in selected villages, supplemented by expert interviews and consultations with individuals familiar with local conditions. Participants were selected from a list of individuals who had taken part in the *Kelussia odoratissima* cultivation project six years prior, obtained from the local natural resources office. Random sampling was then conducted in each village using Cochran's formula (Cochran, 1977). The final sample included five villages (Table 1).

Before conducting the main survey, a pre-test was carried out with 22 participants to refine the questionnaire, particularly from psychological and socio-cultural perspectives. The final sample size was determined using the following formula:

$$n = \frac{N\,(t \bullet s)^2}{Nd^2 + (t \bullet s)^2} \qquad (1)$$

Where:

- **n** = required sample size
- **N** = total population of project participants
- **t** = t-value at 95% confidence level (1.96)
- **s** = estimated standard deviation
- **d** = margin of error (0.1)

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Table 1. Sample Distribution across Villages in Fereydunshar County

Villages	Fereydunshar	Sibak	Nehzatabd	Meidanak	Sardab	Vahdatabad	Mazraeghazi	Cheghyort
Number of participants	58	48	5	8	3	8	3	15
Number of samples (base on Cochran method)	48	48	5	5	3	8	3	13
Performed sample	30	23	-	4	25	-	-	3

Questionnaire Design

The questionnaire was divided into three sections:

1. **Project Participation Details** – This section included questions about participation duration, income satisfaction, methods of project awareness, and other relevant aspects.
2. **Harvesting and Income Data** – Questions in this section focused on seed collection, income from different *Kelussia* products, and financial outcomes.
3. **Demographic and Socioeconomic Characteristics** – This section gathered personal details, including education, age, gender, marital status, and occupation.

To ensure data consistency, the questionnaire incorporated measurement scales based on Likert-type items and odd-ratio evaluations. Data were analyzed using logistic regression models in Shazam, SPSS, and Excel software.

Statistical Analysis

In econometric models, dependent variables are typically continuous. However, in cases where the decision-making behavior follows a binary pattern, models such as logistic regression (logit model) and discriminant analysis are used (Judge et al., 1988). Logistic regression is preferred over discriminant analysis due to its robustness (Duc, 2008).

The logit model evaluates the odds ratio, which represents the likelihood of project acceptance versus non-acceptance. The model is expressed as:

$$\mathrm{Ln}\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_i x_i \qquad (2)$$

Where:

- Pi = probability of participation in the project
- 1−Pi= probability of non-participation
- β0\beta 0 = intercept
- βi\beta i = regression coefficients for independent variables
- xi = explanatory variables

In this study, the dependent variable was the willingness of *Kelussia* harvesters to participate in the project, coded as:

- 1 = Acceptance of participation

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- 0 = non-acceptance

To examine the influence of various factors, multiple regression models were tested, including linear probability models, logit models, probity models, and Tobit models (Judge et al., 1988). The logit model was ultimately selected due to its superior explanatory power.

Variable Selection and Model Evaluation

The analysis involved four dependent variables related to native species conservation and project acceptance. After model evaluation, the cooperation tendency variable (Q4y) was identified as the most reliable indicator.

The following 20 explanatory variables were included in the Shazam econometric software for analysis:

- **Q2:** Years of participation in the project
- **Q6-1:** Income satisfaction from *Kelussia* compared to wheat
- **Q7:** Financial income from *Kelussia*
- **Q9:** Household tradition of *Kelussia* cultivation
- **Q10:** Changes in livestock numbers over time
- **Q12:** Satisfaction with NGO training and awareness programs
- **Q13:** Willingness to participate in similar conservation projects (*e.g.*, *Allium hirtifolium*, another endangered species)
- **Q15:** Satisfaction with external assistance
- **Q18:** Financial improvements since project involvement
- **Q21:** Main occupation
- **Q22:** Agricultural experience
- **Q24:** *Kelussia* cultivation as a secondary job
- **Q26:** Marital status
- **Q27:** Education level
- **Q28:** Head of household status
- **Q29:** Household size
- **Q30:** Type of residence (urban/rural)
- **Q38:** Satisfaction with participation in the project
- **Q39:** Age
- **Q40:** Gender

The logit regression equation used for final analysis was:

Logit(Q4y)=Q2+Q6−1+Q7+Q9+Q10+Q12+Q13+Q15+Q18+Q21+Q22+Q24+Q26+Q28+Q29+Q30+Q38+Q39+Q40\text{Logit} (Q4y) = Q2 + Q6-1 + Q7 + Q9 + Q10 + Q12 + Q13 + Q15 + Q18 + Q21 + Q22 + Q24 + Q26 + Q28 + Q29 + Q30 + Q38 + Q39 + Q40

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Variable name	Estimated coefficient	Standard error	T-ratio	Elasticity at means	Weighted aggregated elasticity	Marginal effect
Q2	-0.36164E-01	0.38133	-0.94836E-01	-0.15649E-03	-0.35895E-02	-0.48178E-04
Q61	0.62585E-01	0.70392	0.88910E-01	0.26472E-03	0.91781E-02	0.70643E-03
Q7	0.53027	1.9181	0.27645	0.55210E-03	0.19411E-01	-0.14345E-01
Q9	-10.768	3.5582	-3.0261	-0.25049E-01	-0.93150	-0.16276E-02
Q10	-1.2217	1.2689	-0.96285	-0.21862E-02	-0.70026E-01	-0.16276E-02
Q12	-0.2461E-01	0.74264	-0.33144E-01	-0.96904E-04	-0.32461E-02	-0.32791E-04
Q13	3.5218	1.0429	3.3769	0.18735E-01	0.59050	0.46918E-02
Q15	-1.5260	0.84449	-1.8070	-0.64298E-02	-0.23171	-0.20330E-022
Q18	-0.59218	1.2249	-0.48346	-0.24181E-02	-0.75357E-01	-0.78891E-03
Q21	-1.0312	1.2442	-0.82876	-0.87231E-03	-0.28984E-01	-0.13737E-02
Q22	0.18589	0.10504	1.7697	0.48838E-02	0.20993	0.24764E03
Q24	-2.1525	1.5622	-1.3779	-0.40269E-02	-0.14739	-0.28675E-02
Q26	7.7722	3.5602	2.1831	0.18460E-01	0.59656	0.10354E-01
Q27	1.1155	0.64082	1.7407	0.49810E-02	0.13595	0.14861E-02
Q28	1.1726	2.8137	0.41674	0.20029E-02	0.61980E-01	0.15621E-02
Q29	-0.21370	0.29218	-0.73140	-0.16235E-02	-0.59573E-01	-0.28470E-03
Q30	-2.5661	2.4518	-1.0466	-0.68047E-02	-0.22683	-0.34186E-02
Q38	1.8048	1.5070	1.1976	0.19085E-02	0.50344E-01	0.24764E-03
Q39	-0.23807	0.12817	-1.8575	-0.13292E-01	-0.48476	-0.31716E-02
Q40	10.718	5.2627	2.0365	0.15518E-01	0.47845	0.14278E-01
Constant	3.3577	12.471	0.26925	0.44792E-02	0.14816	

Model Validation

To ensure robustness, the model was tested across **three different phases** to account for potential errors. The final selected model provided the most accurate predictions of participation behavior.

Results and Discussion

Importance and Socioeconomic Context of *Kelussia odoratissima*

Kelussia odoratissima Mozaff. is a fragrant, self-growing plant traditionally consumed in Iran as a garnish (Ahmadi et al., 2007). From a pharmacological perspective, this species exhibits anti-inflammatory, analgesic, and antispasmodic properties and has been used in traditional medicine for pain relief and blister treatment (Asgary et al., 2004). *Kelussia* contains flavonoids, which provide antiviral, antidiabetic, and anticancer benefits, as well as petaloids, which contribute to ulcer prevention, stomach cancer reduction, and strong antioxidant activity (Dinani et al., 2011). The plant is widely used in cooking, pickling, and as a seasoning (Iravani & Jaberolansar, 2005).

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In the past two decades, increasing road access and population growth among rural and nomadic communities have led to overgrazing, excessive harvesting, and habitat destruction, threatening the survival of *Kelussia odoratissima*. Economic hardships among local harvesters, combined with rising demand for the plant, have resulted in increased prices and severe degradation of its natural habitat. Consequently, this valuable species faces a significant risk of extinction (Salimi et al., 2010).

This plant is endemic to Iran, specifically the Central Zagros Mountains, particularly in Chaharmahal and Bakhtiari Province. Studies indicate that the net revenue from *Kelussia* harvesting is approximately 2.9 times higher than that generated from traditional livestock grazing in the region (Mirtalebi, 2009). These economic benefits highlight the importance of developing conservation strategies that align with local livelihoods.

Survey Findings and Socioeconomic Characteristics

A total of 85 questionnaires were completed by participants involved in the *Kelussia* cultivation project. Of these, 82 responses were analyzed to identify key factors influencing project acceptance. The collected data included social and economic characteristics of *Kelussia* harvesters, summarized in Table 2.

Table 2. Socioeconomic Characteristics of *Kelussia* Project Participants

Parameter	Minimum	Maximum	Standard Deviation	Median	Average
Age (years)	15	70	13.85	42	41.85
Education (years)	0	19	4.57	8	9.05
Marriage (years married)	2	16	2.83	5	5.7
Agricultural experience (years)	0	60	17.91	15	19.7
Years in *Kelussia* project	1	7	0.243	3	3.24

Statistical Analysis and Logit Regression Model

The **logit regression model** identified the most influential factors affecting project participation. The most significant predictors (at **1% significance level**) were:

- **Desire to conduct new experiments**
- **Willingness to participate in similar conservation projects**

Additional significant factors (at **5% significance level**) included:

- **Satisfaction with received assistance**
- **Agricultural experience**
- **Education level**
- **Age**

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- **Marital status**
- **Gender (female participation)**

The final logit model equation is:

$$\text{Ln}\left[\frac{P}{1-P}\right] = -10.768Q_9 + 3.5218Q_{13} + (-1.526Q_{15}) + 0.18589\,Q_{22} + 7.7722Q_{26} + 1.1155Q_{27} - 0.23807Q_{39} + 10.718Q_{40} + 3.3577$$

Where:

- **PP** = probability of participation in the project
- **Q9Q_9** = Household history of *Kelussia* cultivation
- **Q13Q_13** = Willingness to participate in similar projects
- **Q15Q_15** = Satisfaction with received assistance
- **Q22Q_22** = Agricultural experience
- **Q26Q_26** = Marital status
- **Q27Q_27** = Education level
- **Q39Q_39** = Age
- **Q40Q_40** = Gender (Female)
-

Interpretation of Results and discussion

- Age and Participation: Younger individuals demonstrated higher willingness to participate**,** as they are generally more open to risk and innovation. A 1% increase in youth engagement corresponded to a 0.48% increase in participation probability**.**
- Agricultural Experience: Participants with more farming experience showed greater likelihood of engagement**.** A 1% increase in agricultural experience resulted in a 0.2% increase in participation probability**.**
- Marital Status: Married individuals were more inclined to participate, likely due to their greater economic responsibilities**.** A 1% increase in the number of married participants led to a 0.59% rise in project participation**.**
- Education: Higher educational levels were associated with greater project acceptance**.** A 1% increase in education level resulted in a 0.13% increase in participation probability**.**
- Gender Influence: Female participants exhibited a higher tendency to engage in the project, as this variable was statistically significant at the 5% level**.**

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Table 3. Logit Regression Model Estimates for *Kelussia* Project Participation

Variables	Estimated Coefficient	T-Ratio	Weighted Aggregated Elasticity	Marginal Effect
Desire to new experiment**	-10.786	-3.0261	- 0.93150	- 0.143
Desire to participate in the similar project**	3.5218	3.3769	0.5905	0.00469
Satisfaction from received assistant*	- 1.526	-1.8070	-0.23171	-0.002
Agricultural experience*	0.18589	1.7697	0.20993	0.0002
Marriage*	7.7722	2.1831	0.59656	0.01
Education*	1.1155	1.7401	0.13595	0.0014
Age*	-0.23807	-1.8575	-0.48476	- 0.00031
Female*	10.718	2.0365	0.47845	0.014
Constant	3.3575	0.26925	0.14818	----

Likelihood Ratio Statistic (L.R. Statistic) = 43.36, Probability (L.R Statistic) = 0.001

Percentage of Right Prediction = 0.97

Mcfadden R^2 =0.71, Maddala R-Square= 0.41, Esterella R-Square = 0.6

**، *Being statistically significant respectively at 1% and 5%

The results of weighted aggregated elastic reveal that a one percent increase in the number of women will increase the partnership probability by 0.014%. Besides, one important factor to determine policy is the marginal effect. The percent of prediction related to this study is 0.97. It means that the other dependent variable was insufficient and P-value is 0.001. It as well means that the accuracy of this model and dependence variable selection is correct. The percentage of the right prediction in the model was 97.56%. In the other words, 97.56 percentages of participants correctly stated the probability of willingness or lack of desire to perform this project.

The McFadden determination coefficient equals 0.71. i.e., the explanatory variables of the model (affective factors) well describe (approximately 71.3%) the changes in the dependent variable of the model. Thus, this statistic, along with Maddala and Estrella's statistics, show that the explanatory variables of the model well explain the changes in the dependent variable of the model.

This study reviled that socio-economic factors mostly affect rangeland management, as also indicated by Walker and Hodgkinson (2000). Socio-economic characteristics such as age, education, place of current residence, occupation, marital status, income, and the number of family members, among others, have been shown to influence local people thinking, attitudes, and perceptions toward the adoption of innovations (Hassan et al. 2014). While Niyaki et al. (2011) determined the marriage status, number of farm patches, and yearly income from agricultural activities and utilization systems as important socio-economic factors that influence the adoption of medicinal plant cultivation in the Eshkevarat region of Iran. One reason why plants have become increasingly threatened has been the weakening of customary laws that traditionally have regulated the use of natural resources. Such laws have often proved to be easily undermined by modern socioeconomic forces. The most extensive meta-review of socio-economic factors influencing adoption found both positive and negative relationships between age and adoption.

Cultivation of productive, non-woody products is a solution to make a living for local communities for; the rangeland area transferred to each livestock farmer is insufficient and can only supply a very small portion of life expenses (Javadi et al., 2010) "Marketing and profitability of secondary products stimulate the cooperation of local communities for conservation and biodiversity of natural resources", furthermore, (Lybbert et al., 2002) and Seidle et al. (2003) add: "This is strengthened through financial and political supports of government and cooperation of non-government organization."

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The significance of education level ($p<0.05$) proved that the acceptance of new scientific policies by rural communities is increased by any effort, which improves the cultural level of the community. This coincides with the findings of Iravani and Jaberolansar, 2005, who used the logistic model.

Therefore, what is of crucial importance is how the government directs and oversees these projects and how the people are enrolled in them, also the constitution of participatory institutes such as cooperative societies and so on are of importance. Nature conservation policies have increasingly considered the participation of various actors (Cent et al. 2014)

Therefore, it is on the government to help Kelussia farmers with financial and intellectual supports till this product becomes profitable.

The results obtained from Logit regression demonstrate that the estimated coefficient of the variables "satisfaction from received assistant", "Agricultural experience" and "age" are negative, indicating an inverse relationship between variables and the possibility of accepting participation (Duc 2008). This analysis shows that farming Kelussia was not common in former times and that the project benefits from originality. Besides, the participants are not satisfied with the supports of green non-governmental institutes; however, they still want to take part in the project. In other words, their non-satisfaction from assistances is independent of their participation.

Furthermore, the coefficient of variables "desire to perform new experiment", "improvement of farming experiences", "improvement of education", "gender" (female) and "marriage" are positive, showing the direct influence of these variables on the possibility of their participation. The maximum weighted aggregated elasticity is related to the "desire to new experiment" variable. In a way, if the originality of new projects increases at the range of 1%, the desire for participation increase to 0.93%.

It is recommended that after studying the rangeland potentials of different regions because of multi-purposed economic values, the socio-economic factors effective on the acceptation of scientific projects be assessed. We suggest that rural people use land partition to cultivate wild celery and other grain (Mirinejad et al. 2013).

3.5 Policy Implications

The results highlight key factors that should be considered when designing policies for the conservation of *Kelussia odoratissima*:

1. Youth and Education Programs: Providing educational workshops and financial incentives can attract younger participants.
2. Financial Support for Women: Given the strong female participation, gender-focused incentives should be introduced.
3. Economic Incentives for Farmers: Agricultural experience plays a significant role in project adoption; therefore, integrating *Kelussia* cultivation with existing farming practices could enhance engagement.
4. Community Awareness Campaigns: Educating communities on the economic benefits of sustainable harvesting can boost participation.

Conclusion

This study identified the desire to conduct new experiments and the willingness to participate in similar projects as the most influential factors driving community engagement in *Kelussia odoratissima* cultivation. Additional significant factors included satisfaction with received assistance, agricultural experience, education level, age, marital status, and gender (female participation).

The analysis of weighted aggregated elasticity revealed that a 1% increase in new project opportunities led to a 0.93% rise in participation willingness. Furthermore, the probability of partnership increased by 0.014% for every additional female participant. These findings suggest

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that targeted policy interventions, particularly those focusing on innovation, financial support, and gender inclusion, could enhance participation in conservation efforts.

The sustainable management of *Kelussia* is influenced by a combination of ecological, socio-economic, and demographic factors. Failure to account for these interdependencies may result in inaccurate models and ineffective conservation strategies. Therefore, a holistic approach—integrating environmental sustainability with economic incentives—should be adopted to ensure the long-term success of conservation initiatives.

Overall, while the adoption of conservation practices is inherently complex and multifaceted, it is a well-studied and increasingly understood field. Future research should focus on optimizing incentive structures and identifying long-term socio-economic benefits to encourage greater participation from local communities.

Author Contributions

Shadi Teifouri collected the data and analyzed of the results. SayedHamid Matinkhah contributed to analysis and editing of the manuscript. Zahra Jafari edited and submitted the manuscript. All authors reviewed the manuscript.

Data Availability Statement

"Not applicable"

Ethical Considerations

The authors avoided data fabrication, falsification, plagiarism, and misconduct.

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Conflict of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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