

## Assessing Rangeland Conditions and Sustainable Management Strategies in Bamyan, Afghanistan

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### ABSTRACT

Identifying effective solutions for rangeland-related challenges has become increasingly complex. Rangelands cover the majority of Bamyan province and serve as a vital source of meat and dairy production. Most farmers in the region are agro-pastoralists who depend heavily on rangelands as their primary asset, while intensive livestock farming systems remain uncommon. Given the ecological importance and the widespread degradation of natural resources, this study aimed to explore sustainable solutions to prevent further destruction of rangelands in Bamyan. Although previous research has largely focused on identifying causes of degradation, there has been limited attention to practical and localized solutions. This study employed a dual-method approach: (1) a review of library and online resources, and (2) fieldwork using observational tools, semi-structured interviews, and questionnaires based on a five-point Likert scale. Due to the absence of a complete list of farmers, simple random sampling was used to select 110 participants in 2023. The findings indicate that most Bamyan farmers are older, married, and illiterate, with primary agricultural outputs including potatoes, wheat, legumes, and fruits. Factor analysis revealed three key areas for intervention: (1) the role and support of government institutions, (2) the contribution of researchers, and (3) the internal involvement of local beneficiaries. Each of these factors encompasses a range of specific solution-oriented variables. The study highlights the importance of collaborative efforts and researcher engagement in the sustainable management of natural resources in Bamyan.

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## INTRODUCTION

Afghanistan is predominantly characterized by rangeland ecosystems, which cover approximately 30 million hectares—about 45% of the country's total land area (UNEP, 2009; Wily, 2004). In addition to these classified rangelands, a significant portion of "wasteland" or "barren land" is also used for grazing, particularly during the winter months. Consequently, the total grazeable area is estimated to encompass nearly 70–85% of the nation's territory

(Aziz & Yi, 2013; UNEP, 2008). These rangelands are vital for supporting approximately 35 million livestock, providing wildlife habitat, and supplying essential resources such as cooking and heating fuel, building materials, medicinal plants, dairy products, wool, carpets, and open space. Moreover, rangeland watersheds sustain around 4 million hectares of irrigated farmland by feeding springs, streams, and rivers, serving as the backbone of Afghanistan's agricultural and ecological systems (UNEP, NEPA, & GEF, 2009; Bedunah et al., 2010; Miller, 2012).

Bamyan Province is heavily reliant on rangelands, where the majority of residents depend on livestock for their livelihoods. Rangelands account for 1.3 million hectares, or 92.4% of Bamyan's total area, and are primarily used for animal grazing and the collection of plant biomass for fuel (NEPA & MAIL, 2014).

Unfortunately, widespread degradation and overgrazing have severely impacted many of the country's rangelands. Farmers increasingly compete for access to the few remaining productive areas, exacerbating the degradation. While the severity of these issues continues to grow, minimal research has been conducted to identify sustainable solutions. Several policy and management recommendations have been proposed in thematic reports, such as the implementation of community-based natural resource management, the development of legal instruments (laws, policies, regulations), the establishment of a national protected area system, and raising public awareness regarding biodiversity and sustainable use (Groninger et al., 2013; Stanfield et al., 2010; UNEP, 2008).

UNEP's (2003) *Post-Conflict Environmental Assessment of Afghanistan* emphasized the need for long-term, coordinated government action. The report recommended reseeding degraded rangelands, reducing grazing pressure and dryland farming in vulnerable areas, and developing community-based rangeland management plans that include representative areas with controlled or restricted grazing.

Similarly, Ansari et al. (2009) proposed aligning grazing systems with rangeland carrying capacity and resolving stakeholder conflicts as essential steps in sustainable management. However, despite these insights, the practical roles of various stakeholders—especially at the local level—remain poorly understood (Ghulami, 2024).

A process-based and adaptive management approach that encourages collaboration between researchers and local communities is critical to solving these complex challenges. While some institutions have implemented such approaches, in many cases, these efforts have evolved without deliberate planning. Boyd and Svejcar (2009) and Poya and Toshiyuki (2017) emphasized the importance of intentionally fostering collaboration between researchers and managers to address such multifaceted problems.

Pittroff (2011) also emphasized that strengthening traditional communal systems, combined with technical government support, is crucial to preventing further rangeland degradation in Afghanistan. In a study on highland rangelands, Aziz and Yi (2013) recommended fostering policy environments that promote sustainable use, intensifying

fodder production, enhancing climate adaptation strategies, and monitoring highland ecosystems while supporting transboundary conservation.

Mohibbi (2018) emphasized that raising public awareness, providing alternative energy resources, developing integrated and participatory resource management systems, and controlling bush collection can reduce rangeland degradation and land cover change in Bamyan.

Further research conducted in Herat Province (Ghoryar & Mohiqi, 2018) found that revising pasture laws, quarantining grazing areas, preventing the conversion of rangelands into agricultural land, and promoting alternative energy sources could alleviate pressure on shrubland resources. Additionally, conservation measures such as fencing steep slopes and promoting community involvement in range management initiatives were suggested (Mohibbi & Cochard, 2014).

Ghoryar and Roggero (2019) stressed the importance of local stakeholder cooperation and the revitalization of traditional institutions through participatory approaches for effective rangeland management. Similarly, Diogo et al. (2021) emphasized the need to promote coexistence between crop farmers and herders, which could enhance participatory rangeland governance, reduce conflicts, address food insecurity, and improve adaptation to climate variability. However, the prevailing tension between transhumant herders and sedentary farmers increases vulnerability and hampers collaborative land use.

Bamyan, like much of Afghanistan, faces numerous ecological challenges, including drought, floods, landslides, groundwater depletion, dust storms, land degradation, and desertification. These issues contribute to environmental degradation and climate change while reducing forage availability for livestock. This underscores the urgent need for effective rangeland management.

Accordingly, this study seeks to address the following questions:

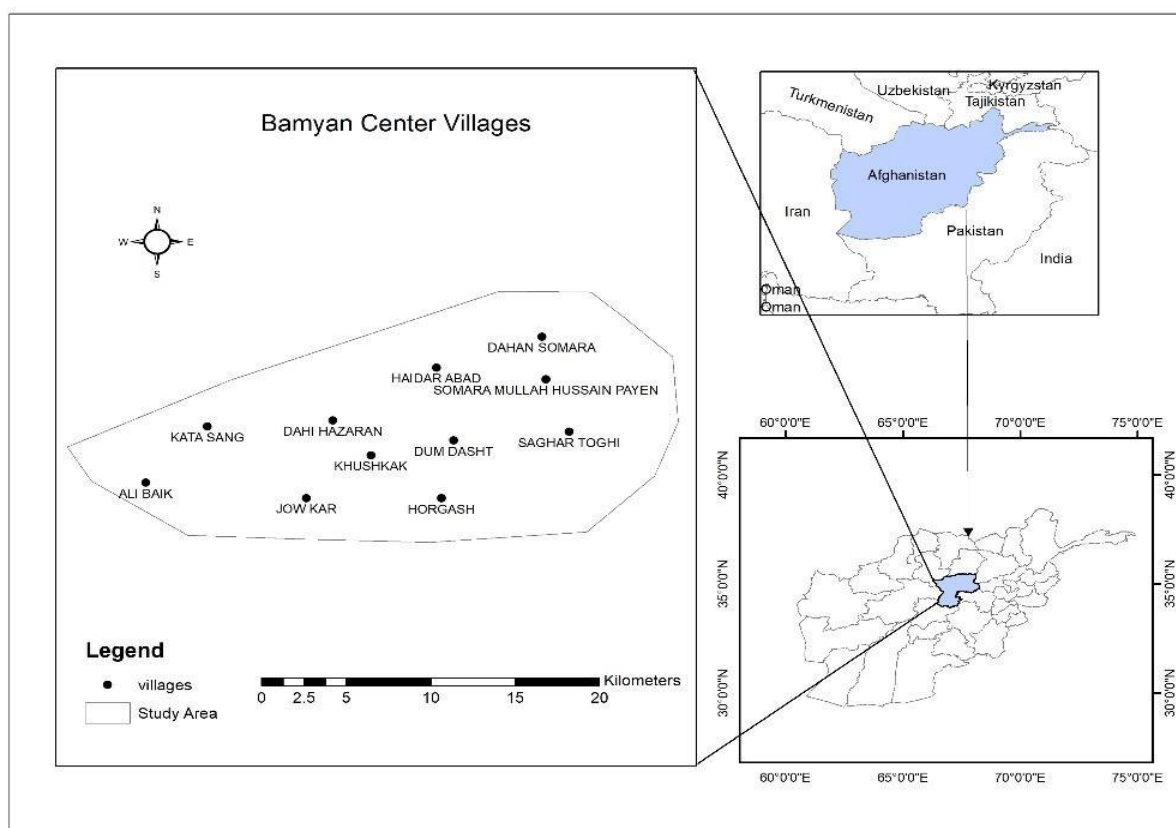
- What are the most effective strategies for preventing rangeland degradation?
- How can the various contributing factors and potential solutions be systematically categorized and analyzed to identify practical solutions?
- While focusing on Bamyan Province, how can the findings inform rangeland management practices in similar ecological and socio-cultural settings?

Rangeland degradation is a complex issue that requires multi-stakeholder collaboration to develop effective solutions. Although significant research has examined the drivers of rangeland degradation, practical solutions to address these issues remain underexplored. Only a limited number of studies have attempted to categorize solution strategies systematically. This study contributes to filling that gap by applying factor analysis to identify the underlying dimensions of proposed solutions. Furthermore, it highlights the often-overlooked role of researchers in Afghanistan's rangeland management discourse.

## Methods and Materials

### Study Area

This study was conducted in four valleys within Bamyan districts: Folady, Dokani, Somara, and Khoshkak. In each of the first three valleys, three villages were randomly selected, while two villages were chosen from the last valley. These valleys are part of a broad and fertile central region, with settlements located both in the lowlands and on the elevated plateaus of the surrounding mountains. The selected sites are situated in proximity to Bamyan City (see Figure 1).



**Figure 1.** Map of eleven villages, four valleys in the center of Bamyan Province, Afghanistan

The local population utilizes biomass from these areas for various purposes, including livestock grazing, as well as heating and cooking fuel, and traditional medicinal treatments. Food production is based on both dryland and irrigated farming. The primary sources of income for residents are agriculture and animal husbandry. The dominant livestock types include sheep, goats, donkeys, and cattle, which provide essential resources such as food, raw materials, and manure. Key crops grown in the area include potatoes, wheat, and barley.

This research is classified as applied research, as it seeks to develop practical knowledge and propose appropriate solutions for preventing rangeland degradation. In terms of methodology, the study follows a descriptive-exploratory approach, employing both primary and secondary data sources. Data were gathered through a combination of literature review and fieldwork. The target population consisted of local farmers in Bamyan Province, surveyed

in 2023. Due to the absence of a comprehensive list of farmers, a simple random sampling method was adopted.

To meet the research objectives, a semi-structured questionnaire was developed. The first section gathered demographic and personal data from the farmers, while the second focused on identifying potential solutions to rangeland degradation using a five-point Likert scale. Data collection was conducted through in-person interviews using a prepared questionnaire.

### ***Population and Sampling***

Defining the statistical population is a fundamental aspect of any research. The target population is defined as the group of individuals to whom the research findings are intended to apply. In this study, the statistical population consisted of 110 farmers across 11 villages in Bamyan Province. Due to the lack of accurate census data on farmers in the region, a random sampling method was used to ensure representative data collection.

### ***Data Collection and Analysis***

Data for this study were collected through two primary channels: library research, encompassing national and international academic sources, scientific reports, and relevant online resources, and fieldwork, which involved direct engagement with farmers through structured questionnaires and face-to-face interviews.

In line with best practices in research methodology (Hafeznia, 2016), data analysis was conducted with attention to methodological appropriateness and validity. The completed questionnaires were coded and categorized for statistical analysis. Descriptive statistics, including frequency, percentage, mean, standard deviation, and coefficient of variation, were used to describe the sample's characteristics. Additionally, inferential statistics and factor analysis were applied to identify patterns and relationships within the data. All analyses were conducted using SPSS software, version 24.

## **FINDINGS**

The results are presented in two main parts. The first part includes descriptive statistics such as frequency distribution, percentage, cumulative percentage, mean, and standard deviation. The second part presents inferential statistics, specifically factor analysis and the examination of relationships between variables, conducted using SPSS statistical software.

Given the complex nature of rangeland degradation, factor analysis was employed to explore the relationships among variables and to group them into core components for better interpretability. The analysis revealed three primary factors influencing rangeland sustainability: the role of the government, the contribution of researchers, and community participation. Each of these factors comprises multiple underlying variables.

## Age

The age distribution of farmers in Bamyan Province was analyzed across five age groups and is presented in Table 1. The results show that the majority of farmers fall into mature and older age categories. The most significant proportion (22.7%) is within the 36–45 age group, and 41.1% are over 45 years old. These findings suggest that the research population is predominantly comprised of experienced and mature farmers. It can, therefore, be concluded that the farming population in Bamyan primarily belongs to the older working class.

**Table 1.** Distribution of age frequency of farmers in Bamyan province

Statistical population groups	age groups (years)	frequency	frequency percentage	cumulative percentage
The age group of farmers (n=110)	Between 18 and 25	15	13.6	13.6
	Between 26 and 35	24	21.8	35.8
	Between 36 and 45	25	22.7	58.7
	Between 46 and 55	23	20.9	79.8
	More than 55	22	20.2	100
	Total	110	100	
	Average age	110	42.38	
Minimum age	17	Maximum age	76	

Source: research findings

## Marital Status

An analysis of the marital status of farmers in Bamyan Province shows that 13.6 percent are unmarried, indicating a relatively small proportion of single individuals among the farming population. In contrast, 86.4 percent of farmers are married, which may reflect a greater sense of responsibility and commitment to their work. Married farmers are also more likely to transfer their agricultural experience to family members and make more efficient use of household resources, thereby improving livestock management and production.

**Table 2.** Broadcast frequency of marital status of farmers in Bamyan province

Statistical population groups	civil status	frequency	percentage frequency
Peasant group (n=110)	Single	15	13.6
	Married	95	86.4
Total	110	100	

Source: research findings

## Educational level

The frequency distribution of educational attainment among farmers in Bamyan Province is presented in Table 3. According to the data, 42.7 percent of farmers are illiterate, while 21.8 percent can read and write without formal education. Additionally, 12.7 percent have completed secondary education, 11.8 percent have not completed high school (12th grade),

and only 10.9 percent hold a university degree. Overall, the data suggest that nearly half of the farming population lacks basic literacy skills, which may pose challenges for the adoption of modern agricultural practices.

**Table 3:** Broadcast frequency of educational level of farmers of Bamyan Province (n=110)

Educational level	frequency	frequency percentage	cumulative percentage
Illiterate	47	42.7	42.7
Primary	24	21.8	64.5
Middle school period	14	12.7	77.3
High school period	13	11.8	79.1
Bachelor	12	10.9	100
Total	110	100	

Source: research findings

### **Descriptive Statistics of Farmers' Production Levels**

As shown in Table 4, the average production levels of major crops are as follows: beans – 156.49 kg, potatoes – 6,756.27 kg, wheat – 1,096.45 kg, vegetables – 10.69 kg, and fruits – 190.46 kg. These figures indicate that potatoes are the dominant crop in terms of quantity, while vegetable production is the lowest, likely due to the cold climate and limited agricultural extension services.

In terms of livestock feed, the average amount of fodder stored by each household for the winter season is 4,522.23 kg from irrigated lands and 5,879.69 kg from natural pastures. This indicates that a significant portion of winter fodder, along with direct grazing during the spring, summer, and autumn months, comes from rangeland sources.

**Table 4:** Descriptive statistics of production level variables of Bamyan province farmers (n=110)

Variable Name	Observations		Mean	Standard Deviation	Minimum	Maximum	Total (Kg)
	Observed	Missing					
Total production Of legumes (Kg)	61	49	156.49	203.819	0	700	9534
Total production of potatoes (Kg)	110	0	6756.27	4646.495	0	24500	743190
Total production of wheat (Kg)	110	0	1096.45	670.497	350	3500	120610
Total production of vegetables (Kg)	44	66	10.69	22.553	0	175	1174
Total production of fruits (Kg)	50	60	190.46	343.602	0	2100	20951
Total fodder production from water fields	110	0	4522.23	4012.345	0	6856	497445
Total fodder collection of natural pasture	105	5	5879.69	5324.879	0	9500	617367

Sources: research findings

### **Identifying and Discovering Key Solutions to Prevent the Destruction of Natural Pastures in Bamyan Province**

To identify practical solutions for preventing the ongoing degradation of natural pastures in Bamyan Province, the questionnaire items and participant suggestions outlined in the

"Solutions" section were analyzed to assess the suitability of the data for factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.69, indicating that the sample was suitable for analysis. Furthermore, Bartlett's Test of Sphericity yielded a statistically significant result ( $p < 0.05$ ), confirming correlations among the variables relevant to this scale.

After validating the dataset, Varimax rotation with Kaiser normalization was applied to extract the key factors. As shown in Table 5, the factor analysis identified three components with eigenvalues greater than 1, accounting for a total variance of 66.321 percent across the dataset. The first factor explained 25.818% of the variance, the second 22.384%, and the third 18.119%.

These results indicate that the solution framework for addressing pasture degradation is composed of three primary factors, each representing a significant portion of the shared variance among variables:

- **Factor 1:** 25.818% of the total variance
- **Factor 2:** 22.384% of the total variance
- **Factor 3:** 18.119% of the total variance

**Table 5:** Statistical indices extracted from the scale of solutions to prevent destruction of pastures using principal component analysis

Factor	special value	Varian's percentage Explained	Cumulative percentage of variance expressed
First factor	2.316	25.818	25.818
Second factor	2.260	22.384	48.202
Third factor	1.576	18.119	66.321

Source: research findings

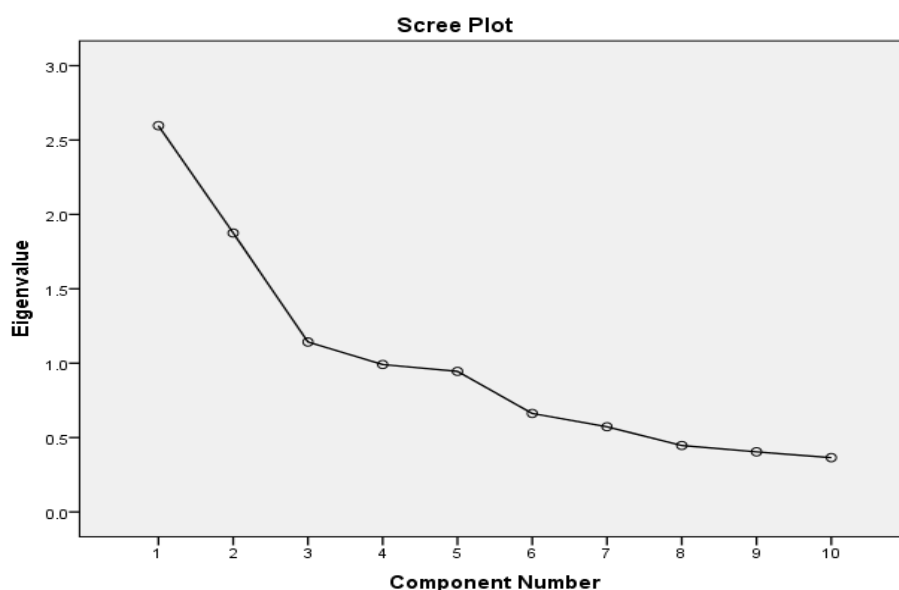
According to the findings presented in Table 5, the first factor, with an eigenvalue of 2.316, shows the strongest correlation with variables such as the identification of agricultural and pasture areas (including rangeland and dryland farming), the provision of alternative energy and fodder, and the revision and improvement of pasture-related laws. This factor alone accounts for 25.818% of the total variance in the solution framework designed to prevent pasture degradation.

The second factor, with an eigenvalue of 2.260, is most strongly associated with three key variables: increased research and serious attention to pasturelands, training of professional personnel for improved pasture management, and the promotion of grazing systems based on carrying capacity. This factor accounts for a significant portion of the explained variance, highlighting the importance of technical expertise and institutional focus.

The third factor, with an eigenvalue of 1.576, includes variables such as limiting bush harvesting, promoting the sustainable use of natural resources, and adopting collaborative management systems. This factor accounts for 18.119% of the total variance, highlighting



the importance of environmental regulation and stakeholder engagement in pasture preservation.



**Figure 2:** Scree test and extraction of scale factors of solutions to prevent the destruction of pastures

Figure 2, the scree plot shown below, supports these results by illustrating that only three factors have eigenvalues greater than 1, confirming their significance in the analysis.

**Table 6:** The variables of each factor and the amount of factor load obtained from the rotated matrix

Factor	Suggested name	Variables	Factor loading
First	The role and attention of the government	Determine dry agricultural land and rangeland areas	0.823
		Preparing alternative energy fodder	0.764
		Technical support correction and amending pasture law	0.641
		Raising the awareness of families	0.598
Second	The role and attention of the government	Serious attention and increased research on the pastures of the country	0.833
		Educate professional employees regarding the promotion and healthy management of pastures.	0.718
		Promotion of grazing systems consideration capacity	0.586
Third	The inner role and participation of the beneficiaries	Limiting bush collection	0.774
		Sustainable use of natural resources	0.608
		Collaborative management system	0.579

Source: research findings

As detailed in Table 6, each factor is composed of several variables. The loading patterns following Varimax rotation are presented to facilitate a more straightforward interpretation and align the variables with distinct thematic axes. Specifically, the first factor includes the following variables: identification of dryland farming and rangeland areas, provision of alternative energy and fodder, raising public awareness, revision of pasture legislation, and

provision of technical support. These elements collectively define the first dimension in the proposed solution framework for mitigating rangeland degradation in Bamyan Province.

## **DISCUSSION**

To prevent the destruction of natural pastures in Bamyan Province, three key factors have been identified. First is the role of the government, which includes clarifying the boundaries between dry agricultural land and rangelands, providing alternative energy sources and livestock fodder, raising awareness among rural families, reforming pasture-related laws, and offering technical support. Second, there is a need for further research and the development of professional capacity in sustainable pasture management. This involves studying pasturelands in-depth, training professionals, and promoting grazing systems based on the land's carrying capacity. Third is the inner role and participation of local communities, which includes limiting bush collection, promoting sustainable use of natural resources, and establishing collaborative management systems. Together, these factors form a comprehensive and strategic approach to preventing pasture degradation in the region.

This research emphasized the importance of land-use classification and legal reform as critical components of sustainable pasture management. Similar findings are supported by Oba and Kaitira (2006), who underscore the role of proper land-use planning and legal frameworks in mitigating rangeland degradation in semi-arid regions. Convertino et al. (2013) also note that weak institutional policies and unclear land tenure contribute to overgrazing and mismanagement. Therefore, aligning pasture laws with sustainable management strategies is consistent with global best practices (Aziz and Yi, 2013). Furthermore, they advocate for strengthening transboundary conservation efforts, promoting sustainable rainfed cultivation, increasing fodder production, developing rural energy solutions, and enhancing climate change adaptation measures.

The introduction of alternative energy and fodder sources to reduce grazing pressure is widely supported (Davies et al., 2016). Reid et al. (2008) argue that reliance on natural pastures can be reduced through supplementary feeding and the adoption of alternative energy sources, such as solar power and biogas. Similarly, Ghoryar and Mohiqi (2018) recommend promoting alternative energy sources, amending pasture laws, implementing pasture quarantine measures, and preventing the conversion of rangelands into agricultural land. These actions not only help preserve rangeland integrity but also strengthen the resilience of pastoral communities.

The findings of this study also highlight the importance of scientific research and capacity-building in pasture conservation. Similarly, Chapin et al. (2015) argue for a knowledge-based approach that integrates traditional and modern scientific knowledge to improve rangeland management. Diogo et al. (2021) emphasize the increasing awareness of the benefits of cohabitation. Likewise, Blench (2001) underscores the value of training pastoralists and extension workers in sustainable grazing practices. Investing in education and local technical expertise is essential for long-term sustainability.

Regarding community participation, this study aligns with studies such as (Ghoryar and Roggero 2019), who highlight the significance of local collaboration and the revival of customary institutions in promoting sustainable pasture management. Mohibbi and Cochard (2014) also found that local participation in research initiatives and environmental seminars can enhance rangeland governance. While these strategies align with broader research, further investigation is necessary to assess their long-term effectiveness in Bamyan. Future research should also examine the interaction between climate change and policy interventions. Integrating remote sensing and GIS technologies could provide valuable data for monitoring pasture conditions and guiding evidence-based decisions.

Based on the research findings, several policy and practical recommendations are proposed. First, policymakers should formally delineate and regulate the use of dry agricultural land and rangelands. Precise land-use classification would reduce encroachment and promote sustainable grazing. Second, the government and development organizations should prioritize the provision of alternative energy sources, such as solar and biogas, and encourage the cultivation of fodder crops to relieve pressure on natural pastures. Third, raising community awareness about the ecological and economic value of pastures should be integrated into rural development programs. Public campaigns, workshops, and school education can shift behaviors and perceptions.

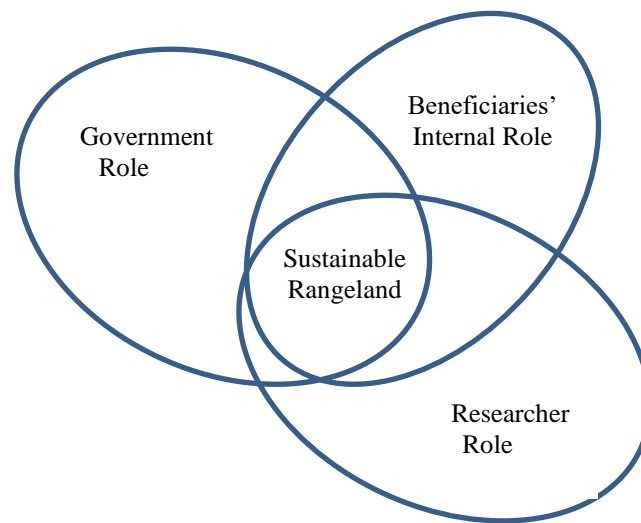
Additionally, existing pasture management laws should be updated to address current ecological challenges. Enforcement mechanisms need to be strengthened, and policies must ensure equitable access while preventing overexploitation. Building local technical capacity through training and supporting research institutions is also essential. Finally, the establishment of collaborative management systems involving government agencies, local communities, and pastoralists is recommended. Such participatory governance can improve transparency, foster community stewardship, and ensure better compliance with conservation guidelines. Implementing these recommendations would foster a more sustainable and inclusive framework for managing Bamyan's rangelands and could serve as a model for other regions facing similar challenges.

## **CONCLUSION**

Rangeland constitutes the primary source of livelihood for 80 percent of the population and covers approximately 80 percent of Afghanistan's land area. In the case of Bamyan province, this figure rises to 92 percent. Effective management of rangelands contributes significantly to both economic stability and environmental sustainability. This study, conducted under the theme of identifying solutions to prevent the degradation of natural pastures in Bamyan, presents several findings. According to the results of descriptive statistics, the majority of livestock farmers in the province are elderly and possess considerable experience in animal husbandry.

Additionally, most are married and illiterate. The main agricultural products of Bamyan farmers include beans, potatoes, wheat, vegetables, and fruits. Among these, potatoes had

the highest average production volume, while vegetables had the lowest—mainly due to the region's cold climate and limited growing conditions. During winter, families collect livestock fodder from both irrigated lands and natural rangelands. This indicates that more than half of each household's winter fodder supply, alongside direct grazing during spring, summer, and autumn, comes from natural pastures. Figure 3 below highlights three essential factors in preventing rangeland degradation: the role and commitment of the government, the contribution of researchers, and the internal participation of local beneficiaries. All three are considered critical for sustainable rangeland management.



*Figure 3. shows the three main factors*

Based on the identification and analysis of key solutions to prevent the destruction of natural pastures in Bamyan Province, several important variables have been identified.

The first factor includes the following variables:

- Delineation of dry agricultural land and rangeland areas
- Provision of alternative energy sources and livestock fodder
- Raising public awareness among families
- Reform and amendment of pasture-related laws
- Provision of technical support

These variables together represent the primary set of solutions to prevent the degradation of natural pastures in the province.

The second factor comprises:

- Increased focus and research on national pasturelands
- Education and training of professional staff for pasture development and sustainable management

- Promotion of grazing systems based on pasture capacity
- The third factor focuses on the following variables:
- Limiting the collection of bushes
- Promoting the sustainable use of natural resources
- Implementing a collaborative pasture management system

Together, these three factors form a comprehensive framework of solutions aimed at preventing the destruction of natural pastures in Bamyan Province.

This study reinforces global research on rangeland conservation by demonstrating the effectiveness of policy reforms, alternative resources, education, and collaborative management in preserving pastures. By comparing our findings with those of previous studies, it is evident that a comprehensive, interdisciplinary approach is essential for sustainable rangeland management. Future efforts should focus on enhancing research, policy implementation, and community participation to ensure the long-term viability of Bamyan province's rangelands.

#### **AUTHORS CONTRIBUTIONS**

All authors contributed to the development of this study. [Author 1 Ghulami G. H.] conceived the research idea, designed the methodology, and led the writing of the manuscript and data analysis. [Author 2 Lali M. N.] assisted in a literature review, data collection, and data analysis. [Author 3, 4 Hazim Z. & Sharafat A.] contributed to the interpretation of findings and revised the manuscript critically for important intellectual content. All authors read and approved the final version of the manuscript.

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#### **CONFLICT OF INTEREST STATEMENT**

The authors certify that they have no financial or personal interests that could have influenced the objectivity or integrity of this research. They further confirm that the work described herein has not been previously published and is not currently under consideration for publication elsewhere. The authors affirm the originality and authenticity of this research in its entirety.

#### **DATA AVAILABILITY STATEMENT**

The data that support the findings of this study are available upon request.

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