

Climate Change Impacts on Animal Health and Livestock Production in Badakhshan Province, Afghanistan

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Abstract

Climate change is one of the most significant environmental and economic challenges of the present century, with substantial impacts on livestock systems and rural livelihoods. The objective of this study was to assess the effects of climate change on animal health and livestock production in Badakhshan Province, Afghanistan. This research was conducted as a descriptive-analytical study using a survey method. Data were collected through a structured questionnaire based on a five-point Likert scale from livestock farmers and officials of the Department of Agriculture. A total of 384 respondents participated in the study. Data analysis was performed using descriptive statistics in SPSS software. The findings indicate that drought, water scarcity, reduction in natural fodder, degradation of rangelands, and extreme weather variations are the main factors affecting livestock activities. Specifically, 80.2% of respondents reported very high impacts of drought on livestock systems, while 90.1% indicated severe reductions in pasture areas due to climate change. In addition, an increase in animal diseases, limited access to veterinary services, and shortages of vaccines and medicines were identified as major challenges in animal health. In terms of livestock production, reductions in milk and meat production, increased costs, and decreased farmers' income were observed. Overall, the results show that climate change has had significant negative impacts on the sustainability of livestock systems and the economic conditions of livestock farmers in the study area. These findings highlight the need for effective climate adaptation strategies, improved veterinary services, and sustainable livestock management practices to enhance the resilience of livestock-dependent communities in Badakhshan Province.

1. Introduction

Climate change is considered one of the most significant global challenges of the twenty-first century due to its widespread impacts on the environment, economy, and global food security. Rising global temperatures, changing rainfall patterns, recurrent droughts, floods, and other extreme climatic events are among the major consequences of this phenomenon (*Intergovernmental Panel on Climate Change, 2022*). The livestock sector is regarded as one of the most vulnerable sectors to climate change because of its direct dependence on natural resources such as water, degradation of rangelands lands, and favorable environmental conditions. Therefore, climate change has emerged as a serious threat to the sustainability of livestock production and the livelihoods of rural communities, particularly in developing countries (*Food and Agriculture Organization of the United Nations, 2021*).

The livestock sector plays a crucial role in ensuring food security, creating employment opportunities, and reducing poverty in rural communities. Animal products such as milk, meat, wool, and hides contribute significantly to household nutrition and income generation. However, climatic factors including rising temperatures, water scarcity, and degradation of rangelands have had considerable negative impacts on animal health and livestock productivity (Nardone et al., 2010).

Increased temperatures lead to reduced feed intake, decreased milk production, impaired growth, and reproductive disorders in animals, ultimately reducing livestock productivity and efficiency (*Thornton et al., 2009*).

Various studies have demonstrated that climate change directly affects animal health. Rising temperatures and changing humidity conditions create favorable environments for the spread of viral, bacterial, and parasitic diseases, thereby increasing the risk of disease outbreaks among livestock populations (*Thornton et al., 2009*). In addition, drought and fodder shortages weaken animals' immune systems and increase livestock mortality rates. These conditions not only threaten animal health but also result in reduced livestock production and substantial economic losses for livestock farmers (*Herrero et al., 2016*).

Afghanistan is considered one of the countries highly vulnerable to climate change because its economy largely depends on agriculture and livestock production. In recent years, persistent droughts, declining water resources, extreme temperature fluctuations, and irregular rainfall patterns have had severe negative impacts on people's livelihoods and livestock activities (*United Nations Development Programme, 2020*).

Many Afghan livestock farmers have faced challenges such as shrinking grazing lands, fodder shortages, increased livestock diseases, and declining animal production, all of which have negatively affected food security and the economic conditions of rural households (*Asian Development Bank, 2021*).

Badakhshan Province was selected as the study area because it is one of the important livestock-producing regions of Afghanistan, where a large proportion of rural households depend on livestock for their livelihoods.

The province is characterized by mountainous terrain, harsh climatic conditions, long winters, and high dependence on natural grazing resources. These characteristics make livestock production particularly vulnerable to climate-related challenges, including drought, water scarcity, pasture degradation, and changes in animal health conditions.

Badakhshan Province is one of the major livestock-producing provinces of Afghanistan, where a large proportion of the population depends on animal husbandry for their livelihoods. The mountainous geography, long winters, and heavy dependence on natural resources have made livestock production in this province highly vulnerable to climate change. Reduction in rangelands, water scarcity, severe cold conditions, and the spread of livestock diseases are among the major challenges livestock farmers in the province have experienced in recent years (*ADB, 2021*).

Despite the importance of the issue, research conducted on the impacts of climate change on animal health and livestock production in Afghanistan, particularly in Badakhshan Province, remains limited. Most previous studies have mainly focused on the general effects of climate change on agriculture and food security, while insufficient scientific information is available regarding its impacts on livestock production and animal health in remote areas of Afghanistan (*FAO, 2021*).

This lack of scientific evidence has created difficulties in planning and developing effective adaptation strategies for climate change in the livestock sector.

Previous studies indicate that climate change not only reduces livestock productivity but also threatens the income and economic sustainability of rural households. Declining milk and meat production, rising veterinary costs, and livestock losses caused by diseases impose substantial economic pressure on livestock farmers and contribute to increased poverty and food insecurity (Herrero et al., 2016).

Therefore, scientific investigation of the impacts of climate change on the livestock sector can play an important role in identifying challenges and developing appropriate adaptation strategies.

Accordingly, the main objective of the present study is to evaluate the effects of climate change on animal health and livestock production in Badakhshan Province, Afghanistan. This study aims to examine the impacts of temperature changes, drought, water scarcity, reduction of grazing lands, and livestock diseases on animal productivity and the livelihoods of livestock farmers. The findings of this research may contribute to policymaking, improvement of livestock management practices, and the development of effective climate change adaptation strategies in Afghanistan (FAO, 2021).

2. Material and Methods

2.1 Study Area

The study was conducted in Badakhshan Province, located in northeastern Afghanistan. The province is characterized by mountainous terrain, diverse climatic conditions, and a predominantly rural population dependent on agriculture and livestock production. Livestock farming plays an important role in the livelihoods of local communities; however, animal production and health are increasingly affected by climate-related challenges, including changes in temperature, precipitation patterns, drought, and extreme weather events. The geographical location of Badakhshan Province, Afghanistan, where the study was conducted, is presented in Figure 1.

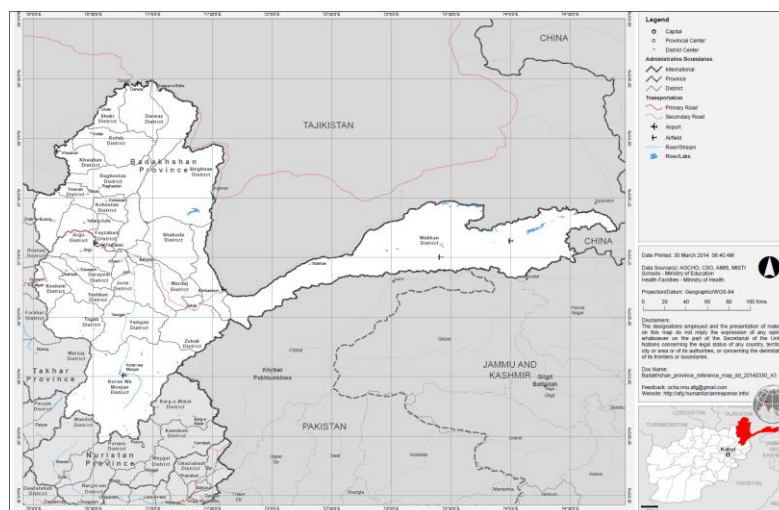


Figure 1. Geographical location of Badakhshan Province in northeastern Afghanistan.

The present study was conducted with the aim of assessing the impact of climate change on animal health and livestock production in Badakhshan Province, Afghanistan. This research was designed as a descriptive–analytical study and implemented using a survey-based approach. This method was selected due to the nature of the research topic and the need to examine the perspectives of livestock farmers and officials from the Provincial Department of Agriculture, as it enables the analysis of relationships among variables in real-world conditions.

The study population included active livestock farmers and staff of the Department of Agriculture in Badakhshan Province. In the livestock farmer group, a sample size of 384 respondents was selected using purposive and convenience sampling techniques. The sample size was determined using Cochran's formula for sample size calculation. Considering a 95% confidence level, a 5% margin of error, and maximum variability ($p = 0.5$), the required sample size was calculated as 384 respondents. Therefore, 384 livestock farmers were selected for participation in this study. In addition, a separate structured questionnaire was distributed among agricultural experts and officials to collect specialized data related to climate change and livestock conditions. All participants took part voluntarily, and informed consent was obtained prior to questionnaire completion. Participants were assured that all collected information would remain confidential and would be used solely for academic purposes.

The survey was conducted between March and May 2025. During this period, data were collected through face-to-face interviews using structured questionnaires administered to livestock farmers and officials of the Provincial Department of Agriculture in Badakhshan Province, Afghanistan.

Data were collected using structured questionnaires. The questionnaire was developed after an extensive review of the relevant literature on climate change, livestock production, and animal health, including publications by the FAO, IPCC, and previous peer-reviewed studies on livestock and climate change. The questionnaire items were adapted from concepts and indicators commonly used in earlier studies and were modified to fit the socioeconomic and environmental conditions of Badakhshan Province, Afghanistan. Before data collection, the questionnaire was reviewed by agricultural and animal science experts to ensure content validity, clarity, and relevance.

The internal consistency of the questionnaire was assessed using Cronbach's alpha coefficient in Statistical Package for the Social Sciences. The questionnaire consisted of 15 items, and the overall Cronbach's alpha

coefficient was **0.794**, indicating acceptable internal consistency and good reliability of the survey instrument. This value exceeds the commonly accepted threshold of 0.70 for social science research.

A five-point Likert scale was used to measure the study variables, ranging from very low to very high. This scale is widely recognized in social and economic research for measuring attitudes and perceptions.

To analyze the data and convert multi-item variables into a single measurable index, a composite index was employed. This index was calculated as the mean of respondents' scores using the following equation:

The composite index for each construct was calculated using the following equation:

(1)

$$CI_k = \sum_{i=0}^n X_{ik}$$

where X_{ik} represents the Likert score of respondents i for item k , and n is the number of items in each construct. All equations were properly formatted using Microsoft Equation Editor and numbered sequentially.

After data collection, all responses were coded and entered into SPSS version 26 for analysis. Data analysis was conducted using descriptive statistics, including frequency, percentage, mean, and standard deviation. Composite indices were also calculated to summarize the overall level of each study variable. Since the study focused on assessing perceived impacts rather than testing causal relationships, inferential statistical tests were not applied.

Given the descriptive–analytical nature of this study, the primary objective was to assess farmers' and officials' perceptions regarding the effects of climate change on animal health and livestock production. Therefore, descriptive statistical methods and composite indices were mainly used to summarize and compare the responses. More advanced statistical analyses were not applied because the study aimed to identify overall patterns and perceived impacts rather than establish causal relationships among variables. From an ethical perspective, all stages of the study were conducted in accordance with scientific principles. Participation was entirely voluntary, informed consent was obtained from all respondents, and confidentiality of the data was strictly maintained.

3. Results

The findings of the study are based on data collected from livestock farmers in Badakhshan Province and are presented in line with the research objectives and variables. Descriptive statistical methods, including frequency, percentage, mean, and standard deviation, were used to analyze the data. The results are systematically organized into three main dimensions of the study, including livestock farming activities, animal health, and livestock production and economic conditions.

The findings indicate that climate change has had a significant impact across all three areas of livestock production. Drought, water scarcity, reduction of natural fodder, degradation of rangelands, and extreme temperature variations were identified as major factors affecting livestock farming activities. In addition, an increase in animal diseases, limited access to veterinary services, and shortages of vaccines and animal medicines were reported as key challenges in animal health. Furthermore, in the area of livestock production and farmers' economy, the results showed a decline in milk and meat production, an increase in livestock maintenance costs, and a reduction in farmers' income.

All results are presented numerically in the corresponding tables and figures, and are referenced appropriately within the text.

Variable	Category	Frequency	Percent (%)
Age	20–30 years	120	31.3
	31–40 years	150	39.1
	41 years and above	114	29.7
Education level	Primary	180	46.9
	Secondary	130	33.9
	Bachelor and above	74	19.2
Livestock experience	1–5 years	160	41.7
	6–10 years	140	36.5
	More than 10 years	84	21.9
Type of livestock	Cattle	140	36.5
	Sheep	150	39.1
	Goats	94	24.5

Table 1 summarizes the demographic and agricultural characteristics of the respondents, including age, education level, livestock farming experience, and livestock types. Overall, the findings indicate that the respondents were mainly young to middle-aged farmers, suggesting an active farming population involved in livestock production. The education profile shows a predominance of lower educational levels, which

may influence farmers' access to technical information, climate adaptation knowledge, and modern livestock management practices.

The results also reveal that many respondents have limited to moderate experience in livestock farming, indicating a need for capacity-building programs and practical training to improve livestock management skills. Regarding livestock composition, sheep and cattle represent the dominant livestock activities in the study area, highlighting their importance for household livelihoods and the local livestock economy.

Table 2. Climate and Environmental Impacts on Livestock (N = 384)

Variable	Category	N	%
Drought has a negative impact on livestock	Moderate	38	9.9
	High	38	9.9
	Very high	308	80.2
Water shortage causes livestock management problems	Very low / Low	38	9.9
	Moderate	38	9.9
	High	231	60.2
	Very high	77	20.1
Natural forage has decreased compared to the past	Moderate	38	9.9
	High	269	70.1
	Very high	77	20.1
Rangelands have decreased due to climate change	High	38	9.9
	Very high	346	90.1
Extreme temperatures affect livestock	Moderate	114	29.7
	High	117	30.5
	Very high	153	39.8

The findings presented in Table 2 demonstrate that climate and environmental stressors are major challenges affecting livestock production in the study area. Among the different factors, drought, pasture degradation, and water scarcity were perceived as the most critical constraints, indicating that reduced availability of natural resources has become a major limitation for livestock sustainability.

The results suggest that declining forage availability and reduced grazing capacity have significantly affected livestock management, reflecting increasing pressure on traditional production systems. Water shortages were also identified as an important challenge, limiting effective livestock management and potentially reducing animal productivity.

In addition, temperature extremes were recognized as an important environmental stress factor influencing animal health and performance. Overall, the findings highlight that climate-related pressures are widespread and are contributing to increased vulnerability of livestock farmers by reducing access to essential resources required for sustainable production.

Table 3. Animal Health and Veterinary Services (N = 384)

Variable	Category	N	%
Animal diseases have increased in recent years	Very low / Low	38	9.9
	Moderate	76	19.8
	High	193	50.3
	Very high	77	20.1
Climate change has increased animal diseases	Very low / Low	0	0.0
	Moderate	38	9.9
	High	76	19.8
	Very high	270	70.3
Veterinary services are insufficient	Very low / Low	76	19.8
	Moderate	77	20.1
	High	38	9.9
	Very high	193	50.3
Lack of drugs and vaccines is a major problem	Very low / Low	0	0.0
	Moderate	77	20.1
	High	193	50.3
	Very high	114	29.7
Livestock owners need animal health training	Very low / Low	0	0.0
	Moderate	0	0.0
	High	38	9.9
	Very high	346	90.1

The findings presented in Table 3 highlight significant challenges related to animal health conditions and veterinary service availability in the study area. Overall, respondents perceived an increasing trend in livestock diseases, with climate change considered an important factor contributing to the deterioration of animal health. The results indicate a strong relationship between environmental changes and disease occurrence, suggesting that climate-related stresses may increase livestock vulnerability and create additional challenges for disease prevention and control. In addition, the limited availability of veterinary services and shortages of essential medicines and vaccines were identified as major constraints affecting effective animal health management.

The findings also reveal a strong need for livestock health training among farmers. This indicates that improving farmers' knowledge and strengthening capacity-building programs could support better disease management, improve preventive practices, and enhance the overall resilience of livestock production systems. Overall, the results demonstrate that improving veterinary infrastructure, ensuring access to medicines and vaccines, and expanding farmer training programs are essential strategies for addressing animal health challenges in the context of climate change.

Table 4. Livestock Production and Costs (N = 384)

Variable	Category	N	%
Milk production has decreased	Very low / Low	38	9.9
	Moderate	230	59.9
	High	116	30.2
	Very high	0	0.0
Meat production has decreased	Very low / Low	115	29.9
	Moderate	269	70.1
	High	0	0.0
	Very high	0	0.0
Livestock maintenance cost has increased	Very low / Low	0	0.0
	Moderate	231	60.2
	High	153	39.8
	Very high	0	0.0

The findings presented in Table 4 demonstrate important changes in livestock production performance and economic conditions in the study area. Overall, the results indicate that livestock farmers are experiencing production challenges, particularly in milk production, which appears to be more vulnerable to environmental and management pressures.

The relatively lower impact observed on meat production suggests differences in the sensitivity of livestock products to climate-related and production constraints. However, the increasing cost of livestock maintenance represents a major economic challenge, placing additional pressure on farmers and potentially reducing the profitability and sustainability of livestock production.

Overall, the findings highlight that climate-related pressures and rising production costs are affecting livestock-based livelihoods. Improving access to resources, strengthening management practices, and supporting farmers through appropriate interventions may help reduce production losses and enhance livestock sustainability.

Table 5. Socioeconomic Impacts on Livestock Farmers (N = 384)

Variable	Category	N	%
Farmers' income has decreased	Very low / Low	0	0.0
	Moderate	76	19.8
	High	232	60.4
	Very high	76	19.8
Climate change negatively affects livestock economy	Very low / Low	0	0.0
	Moderate	0	0.0
	High	76	19.8
	Very high	308	80.2

The findings presented in Table 5 demonstrate the significant socioeconomic consequences of climate change on livestock farmers in the study area. Overall, the results indicate that climate-related pressures have contributed to declining household income and increased economic vulnerability among livestock-dependent communities.

The reduction in farmers' income reflects the broader challenges faced by livestock producers, including production constraints, rising costs, and environmental stresses. Furthermore, the strong perception of negative effects on the livestock economy suggests that climate change is not only affecting animal production but also threatening the financial stability and livelihood security of farming households.

Overall, these findings highlight the need for supportive policies and adaptation measures aimed at reducing economic risks, improving livestock resilience, and strengthening the capacity of farmers to cope with climate-related challenges.

4. Discussion

The findings of this study indicate that climate change has had significant negative impacts on livestock activities, animal health, livestock production, and the economic condition of livestock farmers in Badakhshan Province, Afghanistan. The results reveal that drought, water scarcity, reduction in natural fodder, degradation of rangelands, and extreme weather changes are among the main factors affecting livestock activities and animal production levels. These findings suggest that climate change has become one of the major challenges for the sustainability of livestock production systems in the study area.

The results also show that climate change has a considerable impact on animal health. According to respondents, the incidence of animal diseases has increased in recent years, while access to veterinary services, vaccination, and animal medicines remains limited. This indicates that climate change not only directly affects animal production but also contributes to increased disease vulnerability and weak animal

health management systems. These findings are consistent with previous studies showing that rising temperatures, drought, and environmental stress increase animal vulnerability to diseases and reduce livestock productivity (*FAO, 2022; IPCC, 2021*).

Recent international studies have also reported similar findings regarding the impacts of climate change on livestock systems. Recent evidence indicates that increasing temperatures, drought conditions, and water limitations negatively affect livestock productivity, animal health, and farmers' livelihoods. Studies from different regions have demonstrated that climate change reduces livestock performance through heat stress, feed shortages, pasture degradation, and increased vulnerability to diseases (Hashem et al., 2023; Bonilla-Cedrez et al., 2023; Ateba Boyomo et al., 2024). These findings support the results of the present study, indicating that livestock-dependent communities in vulnerable regions face increasing challenges due to climate-related pressures.

Similar findings have also been reported in neighboring countries and other mountainous regions, where livestock production depends heavily on natural pastures and water resources. Studies conducted in Pakistan, Nepal, and other mountain ecosystems have shown that drought, pasture degradation, and increasing temperatures reduce livestock productivity, increase disease risks, and negatively affect rural livelihoods. These similarities suggest that livestock production systems in mountainous regions face comparable climate-related challenges, highlighting the need for region-specific adaptation strategies.

Furthermore, the results demonstrate that climate change has negatively affected livestock production and the economic situation of livestock farmers. Reduced milk and meat production, increased livestock maintenance costs, and decreased farmers' income were identified as the most important economic challenges. These findings align with studies conducted in vulnerable regions and developing countries, which identify climate change as a major threat to rural livelihoods and food security (*Thornton et al., 2009; FAO, 2021*).

The significance of these findings lies in the fact that livestock is a key source of income and food security for rural households in Badakhshan Province. Therefore, the negative impacts of climate change on livestock systems may increase household economic vulnerability, reduce agricultural sustainability, and pose serious threats to rural livelihoods.

Despite the importance of the findings, this study has some limitations. The study was primarily based on questionnaire data and self-reported perceptions of livestock farmers, which may be influenced by individual experiences and personal bias. These perceptions may not always correspond with objectively measured climatic conditions or production data. In addition, the study was limited to selected areas of Badakhshan Province and may not fully represent all livestock systems in Afghanistan. Time and resource constraints also limited the collection of comprehensive climatic and environmental data.

4.4 Policy Implications for Afghanistan's Livestock Sector

The findings of this study provide important implications for improving livestock policies and climate adaptation strategies in Afghanistan. The observed impacts of climate change on livestock production, animal health, feed availability, and farmers' livelihoods highlight the need for effective policies to strengthen the resilience of livestock systems.

Policy interventions should focus on improving access to quality feed resources, sustainable pasture management, reliable veterinary services, vaccination programs, and climate-related information for livestock farmers. Strengthening agricultural extension services and increasing farmers' awareness of climate adaptation practices are essential steps to reduce the vulnerability of livestock-dependent communities to climate-related challenges.

Furthermore, investment in drought-resistant forage production, water resource management, and animal health infrastructure is necessary to maintain livestock productivity under changing climatic conditions. Collaboration among government institutions, research organizations, and development agencies is also required to develop practical policies that support smallholder livestock farmers and promote sustainable livestock production in Afghanistan.

Based on the findings, it is recommended that government institutions and agricultural organizations strengthen veterinary services, improve livestock farmers' access to medicines and vaccines, and develop training programs on climate change adaptation and animal health management. Furthermore, improving water resource management, supporting fodder production, and developing sustainable rangeland systems are essential to reduce the negative impacts of climate change on livestock production.

For future research, longitudinal studies are recommended to evaluate the long-term effects of climate change on livestock production and animal health. In addition, integrating meteorological data, such as temperature, precipitation, and drought indicators, with livestock performance data would provide more objective evidence on the relationship between climate variability and livestock productivity. Future studies should also focus on developing and evaluating climate adaptation strategies for livestock-dependent communities in Afghanistan.

5. Conclusion

This study demonstrates that climate change is a key factor contributing to the vulnerability of livestock systems in Badakhshan Province, Afghanistan, with clear negative impacts on animal production, animal health, and the socio-economic conditions of livestock farmers. The main climatic factors identified include prolonged drought, water scarcity, degradation of rangelands, reduction in natural fodder, and an increase in extreme weather events. Collectively, these factors have disrupted traditional livestock production systems and reduced their sustainability.

The findings further indicate that climate-induced pressures have led to an increase in animal diseases and limited access to veterinary services. Consequently, livestock production, particularly milk and meat output, has declined, while production costs have increased. This situation has placed additional economic pressure on rural households.

Overall, the results show that livestock production remains a vital source of livelihood and food security in the study area; however, it has become highly vulnerable to climate variability. Without appropriate intervention measures, the sustainability of livestock systems is likely to face even greater challenges in the future.

Therefore, strengthening veterinary services, improving water and fodder resource management, and adapting livestock production practices to changing climatic conditions are essential strategies for mitigating the negative impacts of climate change and ensuring the long-term sustainability of livestock systems in the region.

6. Statements and Declarations

6.1 Competing interests

The author declares that there are no competing interests.

6.2 Data availability

All data used in the article are available within the manuscript, and no additional datasets were generated during the study.

6.3 Ethics Approval

Ethical approval was not required for this study. However, informed consent was obtained from all participants before data collection.

6.4 Approval for animal experiments

Not applicable, as this study did not involve animal experiments.

6.5 Consent to participate/Consent to publish

Informed consent was obtained from all participants prior to data collection. Participants consented to participate in the study and to the publication of the data in an open-access journal.

6.6 Funding

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