

Impact of Climate on Soil Wind Erosion in Karabakh Plain

Dampak Iklim pada Erosi Angin Tanah di Dataran Karabakh

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ABSTRACT

Soil wind erosion in the Karabakh Plain has become a critical environmental concern due to shifting climatic patterns and anthropogenic pressures. This study explores the influence of key climate variables, including wind intensity, rainfall, and temperature fluctuations, on soil erosion dynamics. The research identifies the most erosion-prone periods and regions by evaluating historical climate data and local soil properties. The analysis emphasizes the importance of vegetation cover, optimized land use, and adaptive practices in mitigating soil degradation. However, implementing these measures faces several obstacles, such as limited financial and technical resources, insufficient public awareness, and the intricate interaction between climate and soil systems. The study advocates for a multifaceted risk management approach integrating innovative agricultural techniques, active community participation, and supportive policy frameworks to enhance soil health and reduce erosion. The insights offered a foundation for developing targeted strategies to combat wind erosion and foster long-term environmental sustainability. Furthermore, the proposed measures are adaptable to similar challenges in other semi-arid areas, enabling a broader application of these solutions to enhance resilience against soil erosion.

Keywords: Climate impact, Risk management, Mitigation strategies, Sustainable land use

ABSTRAK

Erosi angin tanah di Dataran Karabakh telah menjadi perhatian lingkungan yang kritis karena pergeseran pola iklim dan tekanan antropogenik. Studi ini mengeksplorasi pengaruh variabel iklim utama, termasuk intensitas angin, curah hujan, dan fluktuasi suhu, terhadap dinamika erosi tanah. Penelitian ini mengidentifikasi periode dan wilayah yang paling rentan erosi dengan mengevaluasi data iklim historis dan sifat tanah lokal. Analisis ini menekankan pentingnya tutupan vegetasi, optimalisasi penggunaan lahan, dan praktik adaptif dalam memitigasi degradasi tanah. Namun, penerapan langkah-langkah ini menghadapi beberapa hambatan, seperti sumber daya keuangan dan teknis yang terbatas, kesadaran publik yang tidak memadai, dan interaksi yang rumit antara iklim dan sistem tanah. Studi ini mengadvokasi pendekatan manajemen risiko multifaset yang mengintegrasikan teknik pertanian inovatif, partisipasi masyarakat aktif, dan kerangka kebijakan yang mendukung untuk meningkatkan kesehatan tanah dan mengurangi erosi. Wawasan tersebut menawarkan dasar untuk mengembangkan strategi yang ditargetkan untuk memerangi erosi angin dan mendorong kelestarian lingkungan jangka panjang. Selain itu, langkah-langkah yang diusulkan dapat beradaptasi dengan tantangan serupa di daerah semi-kering lainnya, memungkinkan penerapan solusi ini yang lebih luas untuk meningkatkan ketahanan terhadap erosi tanah.

Kata Kunci: Dampak Iklim, Manajemen risiko, Strategi mitigasi, Penggunaan lahan berkelanjutan

INTRODUCTION

Climate change and human activities have significantly transformed natural ecosystems and human-modified landscapes worldwide (Ashkenazy et al., 2012). In regions with intricate socio-political contexts, such as areas impacted by occupation and conflict, these issues are further intensified by disruptions to environmental stability and agricultural systems. This study explores the relationship between climate change and human-induced transformations in landscapes, focusing on regions affected by external control. It highlights how land degradation, ecological imbalances, and biodiversity loss combine with climate-induced challenges to create severe ecological and socio-economic repercussions (Bai et al., 2008). Occupation periods often bring unsustainable land-use practices, leading to profound environmental damage. In the examined regions, issues such as deforestation, soil erosion, and inefficient water resource management were prevalent, reflecting broader patterns of environmental challenges (Evans et al., 2016; Hand et al., 2016) in conflict-affected zones. The case of the Armenian-occupied territories highlights how historical and ongoing challenges interact to shape the region's ecological and human landscapes. This research aims to inform policy and practice by exploring these dynamics, contributing to the broader discourse on sustainable development and conflict-sensitive environmental management.

This paper studies the impact of climate on soil wind erosion in the Karabakh Plain, focusing on risk management, the challenges of mitigation strategies, and the effectiveness of current soil conservation techniques in combating land degradation. Monitoring of the effect of semi-arid climate on wind erosion in the Karabakh Plain; Challenges in implementing soil erosion control and risk management measures.

MATERIALS AND METHODS

The Karabakh Plain has undergone significant transformations (Li et al., 2020) over the past 30 years, largely due to geopolitical conflicts and environmental challenges. The region was deeply affected by the war between Azerbaijan and Armenia in the early 1990s, which resulted in widespread displacement, abandoned agricultural lands, and a disrupted economy. Environmental degradation worsened due to overgrazing, deforestation (Mammadova, 2023) and poor agricultural management, leading to soil erosion and reduced fertility. The plain's diverse topography, semi-arid climate (Mammadova, 2014; Mammadova, 2013) and varying soil compositions make it suitable for agriculture and vulnerable to erosion, highlighting the need for effective mitigation strategies.

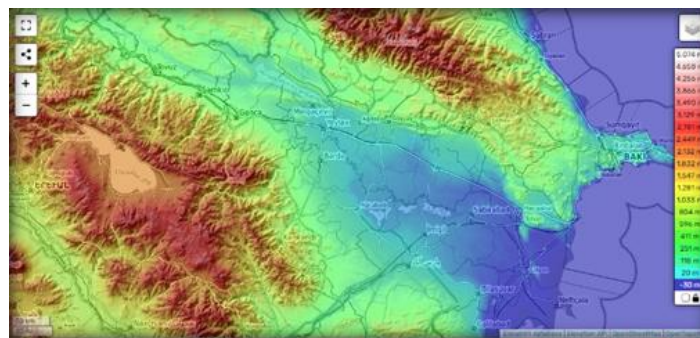


Figure 1. Topography map for the investigation territory

The Karabakh Plain, located in the southeastern part of Azerbaijan, spans a wide area (Mammadova, 2022; Munson et al., 2011; Négyesi et al., 2019) and includes the districts of Beylagan, Imishli, Aghjabadi, Agdam, and Barda. The natural geography of this region is marked by diverse features that significantly influence its ecosystems. The climate of the Karabakh Plain is classified as semi-arid with distinct seasonal variations that influence both the ecosystem and agricultural activities. Summers are typically very hot, with average temperatures often exceeding 30°C, while winters are relatively mild (Skidmore, 1987; Yue et al., 2019) with temperatures ranging between 2°C and 5°. During summer and autumn, the region experiences dry spells, increasing the reliance on irrigation for agricultural productivity. Precipitation levels range from 250 to 500 mm annually, with most rainfall occurring in spring and autumn. The combination of climatic variability, soil degradation (Yang & Cu, 2016) and wind erosion underscores the need for integrated management strategies to ensure the long-term ecological and economic sustainability of the Karabakh Plain. The region's unique challenges require a multidisciplinary approach incorporating traditional agricultural practices and modern technological solutions. Climate change intensifies soil wind erosion in the Karabakh Plain, especially during dry summers. Rising

temperatures, erratic rainfall patterns, and stronger winds reduce soil fertility and accelerate erosion processes. These changes severely limit agricultural activities in the region. Implementing modern conservation measures is crucial in such conditions to protect the soil and combat erosion.

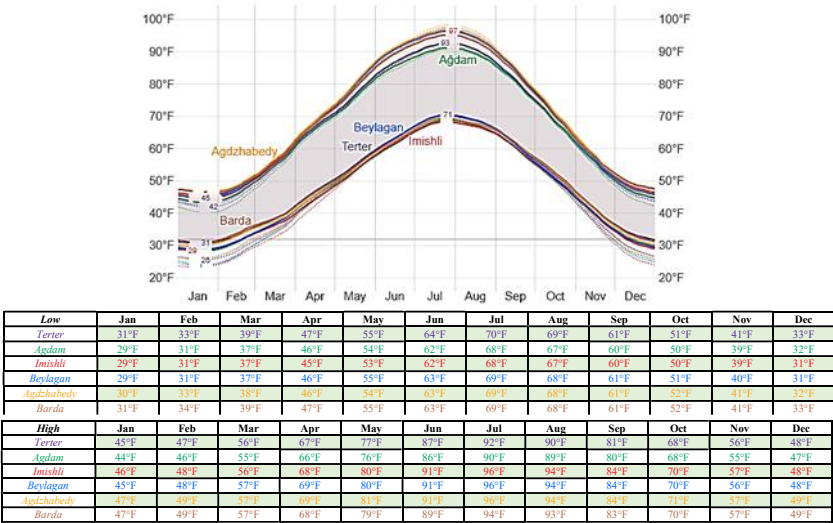


Figure 2. Comparative climate data (low and high)

The region experiences mild winters, gradually warming in spring with highs reaching 77°F (25°C), followed by hot summers over 90°F (32°C) and cooler autumns, with December highs ranging from 45°F (7°C) to 57°F (14°C). There is a need for careful land management to optimize agricultural use and maintain ecological balance. The territory has tourism and agro-opportunities, too.

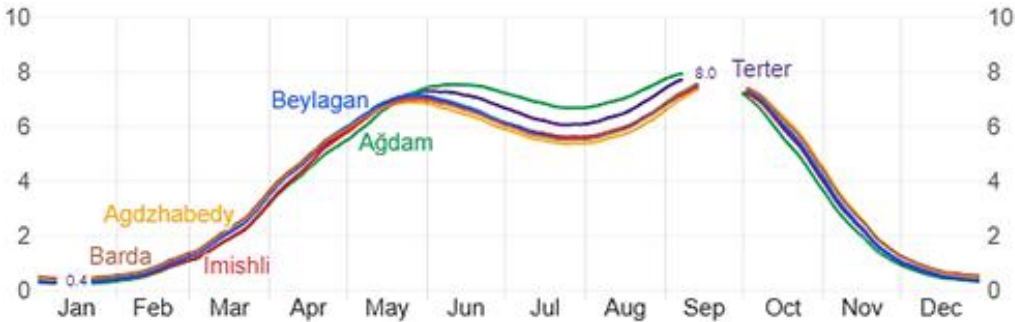


Figure 3. Natural tourism score of Karabakh Plain

The natural conditions of the investigated territory influence its agricultural practices (Wiggs & Holmes, 2011), land use, and overall development. While the region's flat terrain makes it suitable for farming, the semi-desert climate and occasional droughts present challenges that require adaptive strategies in land management, water conservation, and crop selection to ensure long-term sustainability.

RESULT AND DISCUSSION

Climate change has significantly intensified soil wind erosion (Ashkenazy et al., 2012; Mammadova, 2023; Mammadova, 2013; Wiggs & Holmes, 2016) in the Karabakh Plain, with high temperatures, limited precipitation, and fluctuating winds exacerbating soil degradation. Mitigation strategies, such as revegetation programs, sustainable grazing practices, and habitat preservation, are essential to combat this issue. An integrated approach, combining biological (Zhang et al., 2016) and engineering solutions like windbreaks, offers a comprehensive method for reducing soil erosion in the region.

As seen from the legend, the forest area in both districts has decreased steadily from 1500 ha in 1992 to 340 ha in 2024. The reasons for forest area reduction (Yulianto et al., 2023) include: Illegal logging; Forest fires; Agriculture and land use; Infrastructure projects; Climate change; Agricultural expansion; Industrial development; and Ecological disasters. The changes in arable land areas (Ashkenazy et al., 2012; Hand et al., 2016; Mammadova, 2023) in Karabakh Plain from 1992 to 2022 were shaped by agricultural practices, environmental factors, and the

war, with the early expansion of irrigated lands giving way to increased erosion, followed by further agricultural growth that worsened soil degradation, and ultimately land abandonment during the conflict, before reclamation efforts began in 2020. The data collected is below.

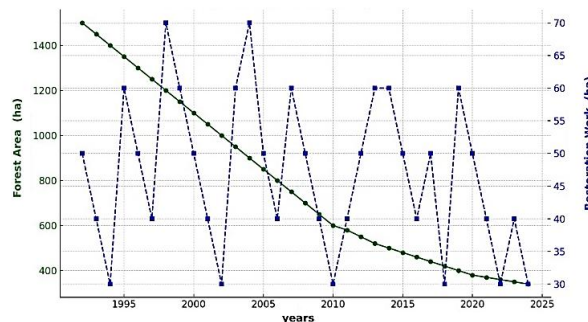


Figure 4. Forest clearing and restoration: Processes, impacts, and ecological significance in Karabakh Plain (1992-2024).

Table 1. Changes in Arable Land areas, causes, and land use impact

Year	Changes in Arable Land Areas
1992-1995	Expansion of irrigated areas, and erosion begins
1996-1999	Expansion of cotton and grain fields
2000-2003	Increase in erosion, land abandoned due to war
2004-2007	Significant reduction in arable land, increase in erosion.
2008-2011	Decreased land use, continued impact of war
2012-2015	Land use decreases due to abandonment and erosion.
2016-2020	Reduced land use
2020-2022	Land restoration and an increase in land use
Year	Causes
1992-1995	Agricultural use, illegal farming
1996-1999	Land use and expansion of farming areas
2000-2003	War, illegal farming, and the destruction of infrastructure
2004-2007	Ongoing war, abandonment of agricultural land
2008-2011	Land destruction, ecological damage
2012-2015	Abandonment of agricultural land and war aftermath
2016-2020	Destruction due to war, land left unused
2020-2022	Land liberated by Azerbaijan, reconstruction efforts
Year	Land Use and Impact
1992-1995	As irrigated areas increase, erosion starts
1996-1999	Arable land expands, productivity increases.
2000-2003	Land use decreases, and arable land is lost.
2004-2007	Arable land and forest areas decrease.
2008-2011	Agricultural land is lost, and erosion increases.
2012-2015	Land use declines, and erosion continues.
2016-2020	Erosion continues, ecological damage persists.
2020-2022	Land restoration begins, and arable land is recovered.

The changes in arable land areas in the plain from 1992 to 2022 have been heavily influenced by agricultural expansion, environmental challenges (Mammadova, 2023; Mammadova, 2024) and the consequences of the war. In the early years, agricultural activities led to the expansion of irrigated land, but soil erosion emerged as a concern due to poor land management. The period between 1996 and 1999 saw further agricultural growth, especially in the cultivation of cotton and grains, which contributed to increased land use and worsened the erosion issue (Mammadova, 2022; Munson et al., 2011). The war, which broke out in the early 2000s, caused widespread abandonment of agricultural lands and infrastructure destruction.

CONCLUSION

The Karabakh Plain's semi-arid climate and seasonal extremes make it highly prone to soil wind erosion, particularly in the hot, dry summers. To address this, key strategies like planting windbreaks, improving vegetation cover, conservation tillage, and efficient irrigation are vital for soil stabilization and preventing further erosion. Effective risk management, including policy reforms, environmental regulations, and community involvement, is essential for maintaining soil health and ensuring sustainable agriculture in the region amidst climate change.

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