

## At the Crossroads of Physics and Climate: A Comprehensive Review of Climate Change in Afghanistan

Seid Aboulghasem Hosseini<sup>1</sup>

<sup>1</sup>Department of Physics, Faculty of Science, Herat University, Herat, Afghanistan

Corresponding author: hseidaboulghasem@gmail.com

### ABSTRACT

Climate change in Afghanistan is important because it has severe impacts on various aspects of life, particularly the agricultural sector, which is the main source of income for the country's economy. More than 80% of Afghanistan's population is involved in farming, herding, or both, despite only 12% of the country's total land area being arable. Climate change is causing successive droughts, health problems, and damage to the environment, animals, and agriculture products in the country. The country has been experiencing an increased frequency of drought since the early 1960s, and it is anticipated that drought could become the norm by 2030. Furthermore, higher temperatures are expected to exacerbate flooding events due to more rapid snow melt in the spring. Climate change also has adverse effects on human health, water resources, and environmental diversity. Therefore, understanding the impact of climate change in Afghanistan is crucial for developing strategies to mitigate its effects and preserve the country's production capacity. This research delves into the mathematical and physical modeling of climate change in Afghanistan.

**Keywords:** Crossroads, Physics, Comprehensive Review, Afghanistan, Climate Change

### INTRODUCTION

Research on climate change is of paramount importance, especially in regions like Afghanistan. Understanding the effects of climate change is crucial for developing strategies to mitigate its impact on various aspects of life, including agriculture, water resources, health, and environmental diversity. By conducting thorough research, policymakers and stakeholders can gain valuable insights into the specific challenges posed by climate change in Afghanistan and develop targeted adaptation and mitigation measures. Additionally, research can help in monitoring and managing the consequences of climate change, ultimately reducing its adverse effects and preserving the country's production capacity (Jawid, 2019). Afghanistan heavily relies on its agricultural sector for income, and climate change has severe impacts on this sector, leading to successive droughts, health problems, and damage to the environment, animals, and agriculture products. The country has been experiencing an increased frequency of drought since the early 1960s, and it is anticipated that drought could become the norm by 2030. Additionally, higher temperatures are expected to exacerbate flooding events due to more rapid snow melt in the spring. Climate change also has adverse effects on human health, water resources, and environmental diversity. Therefore, it is crucial to understand the impact of climate change in Afghanistan to develop strategies to mitigate its effects and preserve the country's production capacity (Nawrozi, 2021). Afghanistan has an extreme continental arid climate that has undergone significant changes since the 1950s, with an increase in temperature and a decrease in precipitation. The impacts of climate change are severe due to the country's high vulnerability and low adaptive capacity, particularly in the agriculture sector. Farmers have tried to adapt, but external support for adaptation has not been sufficient to reduce long-term vulnerability (Gill, 2019).

### MATERIALS AND METHODS

**Physical reasons of climate change:** The physics of climate change is based on the balance between incoming solar radiation and outgoing thermal radiation, regulated by the Earth's atmosphere. The greenhouse effect is caused by greenhouse gases, which trap some of the outgoing thermal radiation and keep the planet warm. Human activities, such as burning fossil fuels and deforestation, have increased the concentration of greenhouse gases, leading to a rise in global temperatures and a range of impacts. Understanding the physics of climate change is crucial for developing effective strategies to mitigate and adapt to its impacts (Nossal, 2017).

**Physical investigation of climate changes in Afghanistan:** The mathematical and physical foundations of the greenhouse effect are rooted in the interaction between solar radiation and the Earth's atmosphere, particularly its greenhouse gases. Here are some key concepts involved:

**Solar radiation:** The Sun emits solar radiation across various wavelengths, encompassing visible light, ultraviolet (UV) radiation, and infrared (IR) radiation.

**Absorption:** Upon reaching the Earth's atmosphere, a portion of the solar radiation is absorbed by greenhouse gases like carbon dioxide, methane, and water vapor. These gases particularly absorb incoming solar radiation in the UV and visible spectrum.

**Reflection:** Some incoming solar radiation is reflected back into space by the Earth's surface, clouds, and other atmospheric particles, known as the albedo effect.

**Emission:** Absorbed solar radiation transforms into heat, subsequently radiated back into the atmosphere as longwave infrared radiation, also termed thermal radiation.

**Greenhouse gases:** Greenhouse gases in the atmosphere, such as carbon dioxide, methane, and water vapor, absorb the longwave infrared radiation emitted by the Earth's surface and re-radiate it back towards the surface. This process traps heat in the atmosphere, leading to a temperature increase, known as the greenhouse effect.

**Radiative transfer equations:** These equations delineate the transfer of radiation through a medium, such as the Earth's atmosphere, accounting for the absorption, emission, and scattering of radiation by the atmosphere and its greenhouse gases.

**Stefan-Boltzmann law:** This law elucidates the correlation between a body's temperature and the quantity of thermal radiation it emits. It states that the energy radiated per unit area per unit time is proportional to the fourth power of the temperature.

**Planck's law:** This law characterizes the spectral radiance of a body at a given temperature, asserting that the spectral radiance is linked to the frequency of the radiation and the body's temperature. In essence, the mathematical and physical foundation of the greenhouse effect involves the interaction of solar radiation with the Earth's atmosphere and its greenhouse gases. The absorption, emission, and scattering of radiation by the atmosphere and greenhouse gases are expounded by radiative transfer equations, while the relationship between temperature and thermal radiation is explicated by the Stefan-Boltzmann law and Planck's law (Ghil, 2021).

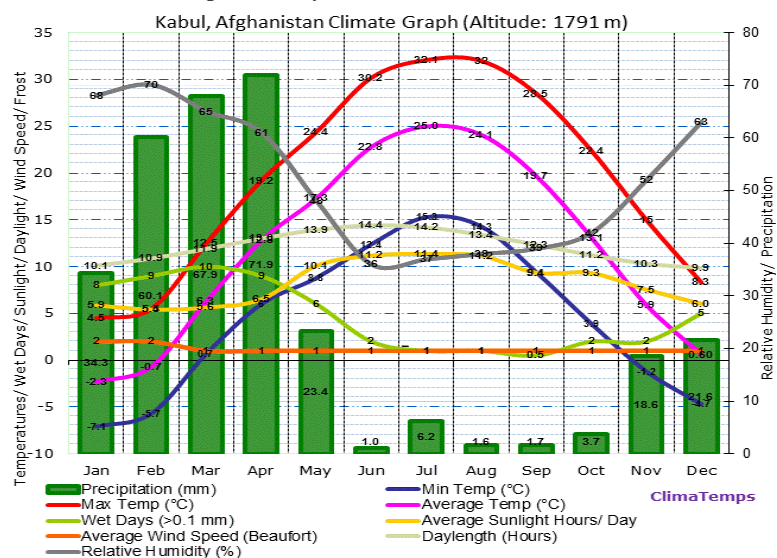
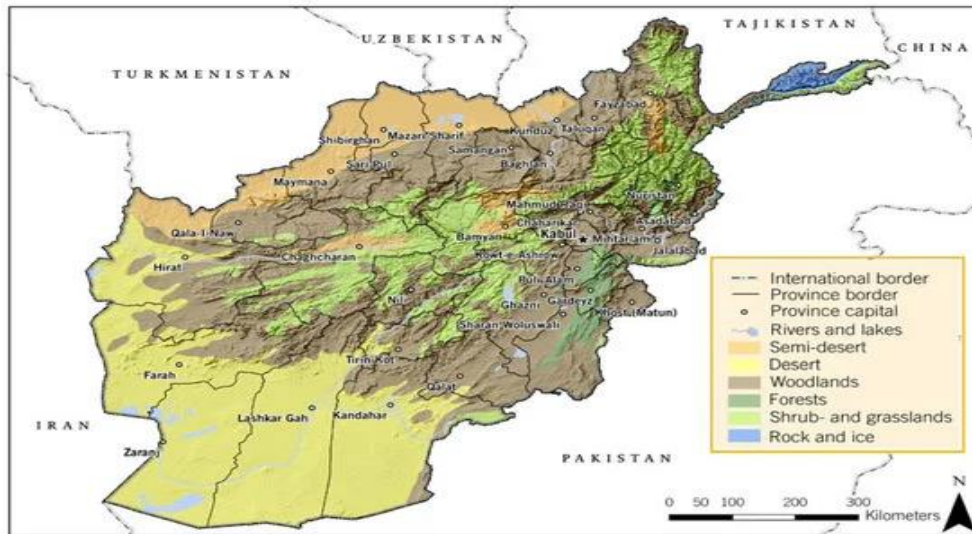


Figure 1. Afghanistan climate graph (Source: www.Climatemps.com)

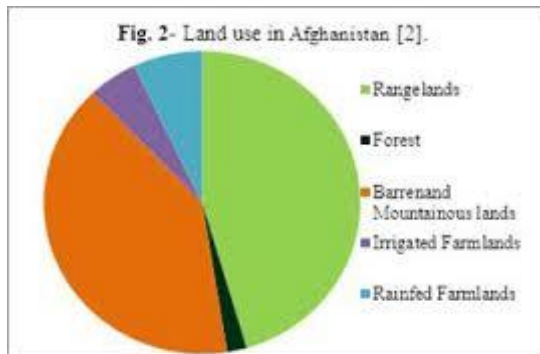
## RESULTS

Climate change has profoundly affected Afghanistan, impacting agriculture, water resources, natural disasters, health, biodiversity, glacial retreat, and contributing to conflict and migration.



**Figure 2.** Geographical map of Afghanistan. (Source: www.mdpi.com)

Agricultural challenges, water scarcity, increased natural disasters, and health impacts such as the spread of diseases are evident. The loss of biodiversity and glacial retreat exacerbate environmental concerns. Additionally, climate change-related impacts contribute to resource scarcity, conflict, and migration. Addressing these challenges requires a comprehensive, coordinated effort at national and international levels, focusing on adaptation strategies and global mitigation initiatives (Nawrozi, 2021).



### Land use:

- Arable land: 12%
- Permanent pastures: 46%
- Forests and woodland: 3%
- Permanent crops: 0%
- Other: 39%

## DISCUSSION

In exploring climate change in Afghanistan from a physics standpoint, the focus is on the scientific principles governing alterations in atmospheric conditions. Changes in temperature, precipitation patterns, and the increased frequency of extreme weather events align with atmospheric physics fundamentals. Afghanistan's vulnerability arises from the intricate dynamics of Earth's climate system, involving interactions between the atmosphere, oceans, and land. The reliance on snowmelt and precipitation for water supply underscores hydrological physics, impacting water availability. Natural disasters, like floods and droughts, are analyzed through fluid dynamics and thermodynamics. Addressing these challenges necessitates scientific modeling, data analysis, and interdisciplinary collaboration to comprehend and mitigate the complexities of climate change on a physical-geographical level.

## CONCLUSION

Human activities, such as burning fossil fuels and deforestation, lead to increased greenhouse gases in the atmosphere, the main driver of climate change. The balance between incoming solar radiation and outgoing

thermal radiation, regulated by the Earth's atmosphere, is critical for maintaining the planet's temperature. Understanding the physics of climate change is essential for developing effective strategies to mitigate and adapt to its impacts.

---

## REFERENCES

- Abdullah Nawrozi, Effects of climate change in Afghanistan, Global Scientific Journals, GSJ: Volume 9, Issue 1, January 2021 ISSN 2320-9186.
- Ghil, Michael and Lucarini, The physics of climate variability and climate change, Reviews of Modern Physics 2021, 92 (3). 035002. ISSN 0034-6861.
- Jawid, Asadullah; Khadjavi, Menusch, Adaptation to climate change in Afghanistan: Evidence on the impact of external interventions, (2019).
- Susan Nossal, Physics of Climate Change, Department of Physics University of Wisconsin-Madison, Physics 301 Physics Today –March 14, 2017.