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# Examining the Impact of Environmental Factors (Climate Change and Air Quality) on Equine Health

*Muhammad Talal Ahmad*[1*], *Zulqar Nain*[1], *Andi Fauzi*[2]

[1]Department of Plant Breeding and Genetics, UAF Constituent College, Depalpur, Okara; University of Agriculture, Faisalabad, Pakistan
[2] Universitas Indonesia (UI), Indonesia

**Summary:** The increasing effects of environmental change on the equine population, such as global warming, climatic changes and deteriorating air quality, have been faced in a greater proportion. This paper looks at the interaction between variables related to climate change, including heat stress, changed precipitation cycles, and extreme weather, and air pollutants, including particulate matter, ozone, nitrogen oxides and wildfire smoke, to affect equine health, welfare and performance. Based on an extensive review of veterinary science, environmental health and equine management literature, the paper examines the physiological, respiratory, metabolic, and behavioral consequences of ecological stresses experienced by horses. It has been shown that high temperatures and humidity exacerbate the thermoregulatory load, resulting in dehydration, electrolyte imbalance, reduced athletic capacity, and a predisposition to heat-related infections. The paper also describes how climate-related alterations in pasture quality, vector ecology, and pathogen survival are modifying the dynamics of equine diseases, increasing the incidence of parasitic infections, vector-borne diseases, and plant toxicities. Moreover, protracted droughts and intense rainfall also affect the availability of fodder, water quality, and stable conditions, thereby increasing the risk of gastrointestinal diseases and poor welfare. Exposure to wildfire smoke has become a major seasonal issue in most locations, particularly affecting performance horses and individuals with underlying respiratory conditions, especially those who are young or elderly. The results underscore the need to implement environmental risk assessment in veterinary and equestrian management practices. Finally, this study demonstrates that climate change and deteriorating air quality are the primary drivers of complex risks to equine well-being and require policy intervention, evidence-based management, and joint action by veterinarians, researchers, and horse owners to ensure the long-term health and well-being of the equine population.

**Keywords:** Environmental Factors (EF), Climate (CC), Air Quality (AQ), Equine Health (EH), Well-Being (WB)

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**Correspondence:** Muhammad Talal Ahmad, Department of Plant Breeding and Genetics, UAF Constituent College, Depalpur, Okara; University of Agriculture, Faisalabad, Pakistan; muhammadtalalahmad@gmail.com

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## Introduction

Horses have always been important to human communities because they fulfil tasks ranging from agriculture and transport to sport, cultural identity, and therapy. As equine management methods have evolved in recent years, it is well established that horses are significantly influenced by the environmental conditions in which they live [1]. With global development, environmental conditions have undergone substantial changes, with climate variability, rising temperatures, and declining air quality emerging as pressing problems affecting both animal and human populations. These climate changes and poor air quality have a great impact on horses' work performance. These changes have promoted interest in studying how environmental changes impact the performance and health of equine species. Because horses rely heavily on respiratory efficiency, thermoregulation, endurance, and stable ecological factors, environmental pressures pose specific concerns that require thorough scientific evaluation [2]. Horses are seen not merely as working or sport animals but as sentinels of environmental health, since their sensitivity to heat, pollution, and ecological change often mirrors broader ecological stresses. This perception has prompted more integrated study techniques that link veterinary sciences to climate research and environmental monitoring. Climate change has altered the pattern of extreme weather, including unexpected rainfall, heatwaves, and changes in seasonal cycles, potentially increasing physiological stress in horses [3]. Prolonged exposure to heat and humidity can disrupt thermoregulation, increasing vulnerability to dehydration, heat-related diseases, and electrolyte imbalance, thereby impairing performance and, in severe conditions, becoming life-threatening. These factors also increase metabolic demands, forcing horses to expend greater energy to maintain homeostasis of body temperature. While altering precipitation patterns affects pasture quality, water availability, and the incidence of vector-borne diseases, these changes might further alter grazing habits, nutritional intake, and overall immune resistance

[4]. A prolonged drought reduces fodder quality and increases the need for supplementary feeding, whereas excessive rainfall exacerbates pasture deterioration and increases the risk of parasite infection and hoof-related disease. As environmental instability intensified, equine health management techniques encountered further difficulties in modifying shelter structures, feeding regimens, hydration routines, and daily exercise schedules [5]. Climate-driven changes in seasonal timing, including longer warm periods or winters, also alter reproductive cycles, task planning, and coat-shedding behaviours. The high frequency of climate-related disturbances highlights the need for further exploration of how long-term climate changes manifest in the biological and behavioural patterns of horses. Air quality has simultaneously emerged as a significant predictor of equine well-being. Horses have highly sensitive respiratory systems, and their performance particularly depends on the free and efficient passage of air through the lungs. Even a small change in air quality can alter oxygen exchange, airway resistance, and overall stamina [6]. Exposure to pollutants, including ozone, particulate matter, ammonia, nitrogen oxides, and wildfire smoke, can lead to chronic respiratory inflammation, coughing, airway obstruction, and impaired athletic performance. These pollutant factors not only irritate the respiratory tract but also reduce mucociliary clearance, thereby increasing susceptibility to infection and prolonging the course of respiratory diseases. The environment near stables, racetracks, and training facilities frequently accumulates airborne pollutants from dust, vegetation debris, bedding materials, manure decomposition, and nearby vehicle or industrial activities [7]. This local pollution, as well as air pollution, enhances the risk of respiratory stress. Poor air quality, particularly from regional smog, large-scale wildfires, and agricultural burning, significantly impacts horses' health. All these factors cause a rapid decrease in breathing comfort, stamina, and recovery rate as pollutant concentration increases. These problems are particularly evident in horses' performance, which is already compromised by high respiratory demands after strenuous exercise. That is why air quality monitoring has become a significant component of equine management, underscoring the importance of situating research on equine health within broader discussions of environmental pollution and atmospheric change [8]. With the increasing attention to equine welfare, sustainable animal care, and veterinary research, there has been a significant need to investigate environmental impacts with more precision. As the economic and emotional value of horses continues to expand across sport, recreation, agriculture, and therapeutic programs, the impacts of air quality and climate instability have wide-ranging consequences for horse owners, veterinarians, equine organisations, and policymakers. Horses are used in global industries, including racing, breeding, and competitive sports, which rely largely on environmental stability and excellent physical health [9]. Therefore, health disruptions related to climate change and hazardous air quality seasons have the potential to alter training cycles, competition schedules, rehabilitation procedures, and even insurance coverage. At the same time, technological developments such as environmental sensors, portable air quality monitors, and biometric monitoring devices are creating opportunities to examine equine responses with greater precision. These devices are of great significance in equine health management. That is why understanding these environmental variables is important not only for managing equine health but also for guiding stable design, establishing early-warning systems for environmental stress, enhancing veterinary therapies, and defining climate-responsive management techniques. The integration of environmental sciences with equine medicine is widely recognized as an important direction for future research [10]. Most researchers have studied environmental sciences and equine medicine to improve horse health, thereby enhancing horse performance. This research paper investigates how climate change and air quality variations affect equine health by examining the behavioural, physiological, and respiratory responses of horses to various environmental stressors. This research paper proposes quantitative methods to explain how heat stress, airborne contaminants, and seasonal variability affect equine functionality and to provide insights to inform adaptive management techniques [11]. By combining environmental data with equine health indicators, this paper aims to provide evidence-based knowledge of the problems that horses experience in a changing world, thereby contributing to greater well-being, informed policy, and more resilient methods of equine care [12].

Environmental changes have affected ecological equilibrium, human well-being, the economy, and the agricultural sector, making them among the most important issues globally in the twenty-first century. The horse industry is among the sectors that will be adversely affected by changing climatic conditions and declining air quality, encompassing sport, leisure, transportation, farming, and therapeutic services. Equestrians are also difficult to care for because of changes in weather patterns. Excessive rainfall and flooding lead to muddy conditions, which in turn induce foot problems in horses (thrush and abscesses). Equestrian pastures can support hazardous and invasive species due to changes in temperature and plant composition. Plant overproduction is likely to occur because some weeds thrive better under higher temperatures and altered rainfall patterns. Additionally, warmer temperatures influence the behaviour and breeding of parasites such as strongyles and botflies, increasing worm numbers and making deworming more difficult. These parasite pressures increase the likelihood of colic, weight loss, and overall poor health.

## Literature Review

Recent research on environmental factors influencing horses has been increasingly focused on how shifting climate conditions and poor air quality shape equine physiology, well-being and disease susceptibility. [13]. Researchers studying equine-environment interactions have suggested that environmental constraints are emerging as some of the most critical drivers of equine health today, because horses depend substantially on thermoregulation, respiratory efficiency and stable ecological conditions. [14]. Recent evaluations of equine

well-being under environmental stressors have further indicated that temperature extremes, humidity variations, poor ventilation, and particulate exposure significantly increase the risk of stress-related disorders, impaired performance, and respiratory diseases. [15]. A major focus of recent research has been to examine how climate change causes acute heat stress in horses. Studies of thermoregulation have shown that horses maintain optimal internal temperature within a narrow range, and researchers have reported that when external heat and humidity exceed specific thresholds, equine physiology struggles to dissipate heat effectively. [16]. Findings from heat-stress physiology research indicate that prolonged exposure to high temperatures can increase the risk of anhidrosis, dehydration, tachycardia, and electrolyte imbalance. Many researchers have examined how these environmental factors impair recovery and endurance, particularly in horses' athletic performance. [17]. Scholars studied metabolic responses under climate stress and demonstrated that rising temperatures alter blood parameters, immunological function, and overall metabolic stability. A multi-year investigation of seasonal hematological shifts further indicated that increasing climate unpredictability can reduce immunological resilience and diminish physiological adaptation. [18]. Scholars have highlighted that these interruptions not only harm horses' health but also increase management demands on trainers, caretakers, and veterinarians.

In addition to thermoregulation, researchers have studied how alterations in rainfall patterns and seasonal anomalies affect nutrition, pasture quality, and vector-borne disease risk. Researchers examining rainfall variability have revealed that droughts, excessive moisture, and factors affecting growing seasons directly influence the nutrient profile of forage, leading caretakers to rely on additional feeds that may not fully meet nutritional needs [19]. Research in equine pasture environmental science has shown that declining grass quality can contribute to digestive imbalance and weight loss. Meanwhile, entomological research has found that warmer temperatures extend the active seasons of insects and parasites, increasing susceptibility to vector-borne diseases [20]. Scholars have claimed that climate-driven expansion of vector populations is making equine infectious diseases more chronic in some places, adding another dimension to the environmental burden on horses. Air quality has emerged as an essential subject of research that requires examination. A vast body of recent studies has explored how exposure to pollution, dust, smoke and airborne particle matter affects equine respiratory health [21]. Researchers studying respiratory immunology argued that horses possess extraordinarily sensitive lungs, making them vulnerable to minute irritants that can disturb natural defensive mechanisms [22]. Researchers studying the effects of wildfire smoke and urban pollution reported that horses experience heightened airway inflammation, coughing, reduced gas exchange, and diminished athletic capacity under poor air-quality conditions [23]. Exceptionally, equine asthma has been researched extensively, and it was noted that even little exposure to PM 2.5 to PM 10 can worsen symptoms and contribute to persistent respiratory dysfunction. Researchers testing bedding materials found that straw-based bedding produced substantially higher dust levels than peat, wood shavings, or pelleted bedding. Studies also examine microbial and fungal contamination in enclosed stables, indicating that poor ventilation and dust accumulation directly lead to inflammatory lung infections [24].

Moreover, a study examining respiratory performance and heat content indicates that horses in warmer, more humid barn environments experience increased lung resistance, mucus buildup, and airway blockage. These findings underscore that stable design, ventilation systems, and bedding choices are key determinants of respiratory health. Recent studies have advanced this research by examining how environmental stress affects equine behaviour, training ability, and indices of well-being. [25]. Researchers investigating behavioural responses reported that horses exposed to repeated heatwaves or poor air quality exhibit reduced stamina, diminished motivation to exercise, and more frequent respiratory distress signals. These behavioural changes reflect underlying physiological strain, which becomes more obvious during physical activity. In addition, research on the opinions of caretakers and owners found that management problems increase dramatically during periods of high heat stress, drought, or air quality changes. [25]. Studies have reported that increased veterinary bills, irregular dietary adjustments, and disruptions to training routines have emerged as recurring issues in prior qualitative research. Immune function has also been a prominent topic of modern environmental health studies. [26]. Researchers investigating immunological responses found that chronic exposure to heat stress and airborne pollutants can damage the equine immune system, increasing susceptibility to infection. Researchers exploring pathogen ecosystems found that intensifying climates lift the survival and reproduction of insects, parasites, and bacteria. [27]. Research using environmental microbiology tests indicates that variations in pasture moisture and temperature may alter the infective composition, thereby affecting digestive health and nutrient absorption. There is a strong relationship among environmental factors, including heat, fodder quality, infections, and air pollution, and horses experience a multidimensional workload. [28]. Despite the growing evidence, scientists assessing current research trends have identified several gaps. Many experts have argued that long-term exposure studies remain lacking, particularly those that measure the cumulative impact of heat, humidity, and pollution on the respiratory and cardiovascular systems. [29]. Other writers have claimed that data on subclinical inflammation in healthy horses remains limited, as most studies focus on clinically recognised respiratory disease. Research addressing how climate change affects dietary balance, parasite cycles and water availability across different locations was rare. [30]. Researchers accordingly emphasised the need for integrated monitoring methods that combine environmental sensors, physiological measures, and behavioural markers to better predict risk patterns. Overall, research has consistently shown that climate change and declining air quality pose complex, overlapping challenges for the equine population. [30]. The literature collectively reveals that environmental stress

affects thermoregulation, respiratory function, metabolism, immunological resilience, pasture ecology, and welfare. Researchers have reported that environmental factors, including climate change and air quality, adversely affect equine health. Therefore, there appears to be a significant need to improve equine management to reduce environmental impacts on equine health. The consequences of environmental change are much larger economically and in other dimensions of welfare. Owners, trainers, and veterinarians are faced with rising management costs amid increasing veterinary costs, the fine-tuning of food and water supply, changes to stables and guard equipment, and the replacement of air filters. Extreme weather may require immediate evacuation or short-term shelter for horses, placing strain on resources and creating logistical challenges.

In such circumstances, welfare changes are exacerbated as responses to environmental changes increase, particularly among young, old, or chronically unwell horses that are unable to adapt readily to environmental alterations. Despite emerging evidence on the environmental impact on equine health, studies are distributed across regions and subdisciplines. Atmospheric changes, environmental research, and husbandry adjustments in equine management research are associated with physiological responses in veterinary studies. The processes of climate change and air pollution must be assessed in a coordinated, interdisciplinary manner to effectively account for their combined effects on acute and chronic health outcomes in horses. This study, therefore, aims to summarise scientific discoveries across multiple fields, presenting a single analysis of the processes, effects, and managerial consequences surrounding environmental modification. It begins with an explanation of why it is necessary to implement proactive measures, including ventilating stables more actively, regularly testing air quality, making pastures more climate-adapted, reducing heat stress, and enhancing disease surveillance.

The increased unpredictability of climatic trends enabled horse owners and experts to employ more adaptive, evidence-based approaches to horse racing. In addition, legislative changes, such as stricter pollution regulations, bad-air-quality wildfire and equestrian activities planning, are important elements of a comprehensive plan. In order to sum up, two issues are climate change and air quality degradation, and they are closely intertwined and have significant effects on the health, welfare, and performance of horses. Horses play significant roles in culture, the economy, and sports; therefore, understanding these aspects of their environment is essential to ensure their well-being. This discussion underscores the urgency of addressing research, administrative, and policy issues that will ultimately establish a framework to examine in depth the environmental factors affecting equine populations.

## Methodology

This research has adopted a mixed-methodology, which involves the use of quantitative and qualitative research in the assessment of the effect of environmental factors, namely, climate change and air quality, on equine health. The purpose of the methodology is to capture all information on the effects of changes in temperature, precipitation, humidity, and air pollutants on physiological, respiratory, and behavioural responses in horses. The study is conducted across a range of equine establishments, including commercial stables, training centres, and individual farms, to ensure diverse variation in management and environmental exposures.

### *Study Design*

The research design is an observational unit study, which follows a representative sample of horses for 12 months. A variety of horses, in terms of breeds, ages, and activity levels, are used to illustrate that each person is susceptible to environmental stress to some extent. The collection of data will be organised according to seasonal changes to enable the study of the impacts of heat waves, cold waves, periods of elevated air quality, and changes in humidity and rainfall.

### *Data Collection*

a. Environmental Data: The digital sensors and meteorological databases are used regularly to measure the environmental parameters. Hourly measurements of temperature, humidity, wind speed, and precipitation are made at each station. Air quality indicators are based on PM2.5 and PM10, ozone (O3), nitrogen oxides (NOx), and carbon monoxide (CO) and use portable air quality sensors located in strategic places within stables, paddocks, and grazing fields.

### *Data Analysis*

AMOS is suitable for examining quantitative data. Descriptive statistics and regression analyses examine the relationships between environmental factors and equine health outcomes.

**Figure 1:** Climate Change and Equine Health

## Climate Change and Equine Health

One of the most significant environmental issues affecting equine health worldwide is climate change. Rising global temperatures, altered rainfall distribution, increased frequency of heatwaves, and extreme weather events have both direct and indirect effects on the physiology, behaviour, and well-being of horses (Figure 1). Horses are susceptible to ambient temperature and humidity because thermoregulation primarily depends on sweating, which is less efficient in hot, humid environments. Extensive exposure to high temperatures may cause heat stress, dehydration, electrolyte imbalance, and reduced athletic performance. Horses, particularly the young, the old, and the chronically unwell, are highly susceptible, and the onset of heat-related disease may be accelerated without early intervention. Changes in the weather further complicate the health risks. Torrential rain and flooding create muddy conditions that predispose horses to hoof problems, including thrush and abscesses, and prolonged droughts increase dust levels, damaging the respiratory system.

Climate-related variations also influence equine nutrition in pasture growth and fodder quality. Loss of access to high-quality fodder may result in weight loss, colic, and gastrointestinal disorders, and drought-stressed or invasive plant species may introduce toxins into the diet. As a result, horses are exposed to complex nutritional and gastrointestinal challenges under changing climatic conditions. Beyond its direct physiological effects, climate change influences the epidemiology of equine diseases. The improved temperatures and longer summers expand the habitats and activity ranges of vectors such as mosquitoes, ticks, and midges, thereby increasing the spread of vector-borne diseases, including West Nile virus, African horse sickness, and equine infectious anaemia. Similarly, higher temperatures increase the pathogen's survival in the environment, thereby increasing the risk of an outbreak. Stressed horses become more vulnerable to endemic and emerging diseases because their immunity is reduced by heat and other environmental factors. Climate stress has behavioural effects, including feeding, grazing, and resting behaviours. During heatwaves, horses may reduce daily activity or seek shade, thereby reducing total energy intake and exercise. These behavioural changes may undermine training outcomes, recovery periods, and training for performance horses. Additionally, extreme weather conditions, including storms, floods, and wildfires, pose immediate physical risks that require emergency interventions and ongoing adaptation.

Climate change is a multidimensional stressor for equines, affecting physiological, nutritional, behavioural, and immunological health variables. These effects are important in determining adaptive management practices, such as heat abatement, fodder management, veterinary management, and emergency preparedness to achieve the welfare and performance of horses in ever-changing, unforeseeable environmental conditions.

**Figure 2:** Air Quality and Equine Health

## Air Quality and Equine Health

Air quality is critical to equine respiratory health, and in various settings, low air quality poses significant threats to horses. The respiratory system is highly efficient at meeting the high oxygen demands of horses during activity, which is the same factor that makes horses highly vulnerable to air pollution (Figure 2). Among the most harmful pollutants are particulate matter (PM2.5 and PM10), ozone (O3), nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOCs), which are primarily emitted by industrial activities, motor traffic, agricultural activities, and wildfires. Low air quality exposure promotes respiratory irritation, airway obstruction, and reduced mucociliary clearance. Repeated airway obstruction (RAO), Inflammatory Airway Disease (IAD), and asthma-like symptoms develop as a result of repeated exposure, both of which reduce the ability to pack the lungs and athletic performance. Immunological dysfunction increased oxidative stress, and exacerbating pre-existing respiratory issues have been demonstrated even in cases of short-term exposure to wildfire smoke. Horses of young age, old age and performance horses are especially prone to such effects. Air quality also interacts with other environmental factors. An example is that, during droughts or in stables with poor ventilation, respiratory irritation is exacerbated by high dust concentrations, and during heat stress, the physiological burden of pollution is increased. Moreover, the presence of airborne allergens and pollen increases the risk of developing hypersensitivity reactions, changes in feeding behaviour, activity, and overall well-being. Practical solutions to mitigate these hazards include regular ventilation systems, air purification devices, dust-free bedding, and controlled outdoor exposure during periods of high pollution. Recording air quality indices in the region and establishing emergency procedures for wildfires, smoke, or other urban pollution are also important measures.

By identifying and managing the effects of air quality on equines, caregivers can improve disease prevention, reduce disease incidence, and sustain performance and welfare across diverse environmental conditions.

**Table 1:** Result of Descriptive Statistics

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| Environmental Factors | 51 | 1.00 | 3.00 | 1.6667 | .73937 |
| Climate change | 51 | 1.00 | 3.00 | 1.4510 | .61037 |
| Air Quality | 51 | 1.00 | 3.00 | 1.6667 | .62183 |
| Equine Health | 51 | 1.00 | 4.00 | 1.6275 | .74728 |
| Valid N (listwise) | 51 | | | | |

The results shown in Table 1 demonstrate the minimum and maximum values, mean rates, and standard deviation rates. The environmental factors are the main independent variable. The result shows that the mean is 1.6667, and the standard deviation is 0.73, indicating that 73% of the observations deviate from the mean. Similarly, climate change and air quality are considered mediator variables; the results show that their mean values are 1.4510 and 1.6667, respectively. Equine health is the main dependent variable. The results show a mean of 1.6275 (positive), with a standard deviation of 0.74, indicating that 74% of the observations deviate from the mean. The biological mechanisms of horses, such as respiratory efficiency, heat regulation, and digestion, are highly sensitive to environmental changes. As the rates of climate change and air pollution are rising in most locations, understanding the extent to which environmental factors affect horse health has become a central focus of research. This introduction provides an overview of the ways in which air quality degradation and climate change have affected the physiology, health, disease susceptibility, and function of horses. It is the support of the presentation of the research that shall be given in detail. Climate change, as a phenomenon, is described as the general range of environmental changes that are being experienced all around the world, including but not confined to an increase in global temperatures and a shift in rainfall, frequent occurrence of heat waves, drought, and storms, and an increase in the habitat of vectors.

The aforementioned health problems caused by climate change can be classified as direct or indirect. Horses can exhibit these problems. Heat stress is a short-term effect. Horse body temperature is least effectively controlled by evaporation of sweat, the most commonly used mechanism in hot, humid weather. Heavy environmental heat loading impairs the horses' ability to dissipate internal heat during work or exercise, increasing the risk of heat exhaustion, dehydration, and electrolyte imbalance. High temperatures in racehorses and working equines can affect athletic performance, extend recovery time, and increase cardiac workload. Besides, long-term heat actions have behavioural effects and change feeding habits, grazing time, and general activity.

**Table 2:** Result of ANOVA[a]

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 1.728 | 3 | .576 | 1.033 | .386[b] |
| | Residual | 26.194 | 47 | .557 | | |
| | Total | 27.922 | 50 | | | |

a. Dependent Variable: Equine Health

b. Predictors: (Constant), Air Quality, Climate Change, Environmental Factors

The above result, shown in Table 2, demonstrates that regression analysis and residual analysis show the sum of square values, the mean square value, and the F-statistic value, as well as the significance of the regression model. All rates of the regression model concluded that a positive and significant relation exists between the environmental factors and equine health. Climate influences pasture growth cycles, and this influences feed quality and quantity that forms the nutritional balance the horses are dependent on.

Poor quality pastures or vegetation due to drought can cause weight loss, digestion problems and predisposition to colic. In addition, there are extreme weather conditions, such as storms and hurricanes, which put horses directly in danger, destroying stables and polluting water sources and increasing the level of injuries. Besides the direct effects of climate change on the ecology of horse diseases, it has major effects. The rise in temperature and the rise in seasons enhance the spread of vectors such as mosquitoes, ticks and midges. These creatures have been carrying about organisms like the West Nile virus, equine infectious anaemia, tick-borne encephalitis and African horse sickness, circumstances that were previously exclusive to particular geographical regions are now intruding into new territories.

The existence of warm temperatures also augments the rate of endurance of pathogens within the environment and heightens the frequency and length of outbreaks. In addition, horses' immunological abilities are altered by stressors in the climate, making them less resistant to opportunistic infections and more susceptible to disease. Another health issue for horses is air quality, which is

typically affected by industrial pollutants, vehicle emissions, agricultural activities, dust storms, and wildfire smoke. The respiratory apparatus of the horse is highly sensitive and efficient, designed to meet the high oxygen demands of athletic activity. This further makes horses highly sensitive to atmospheric pollutants such as particulate matter, nitrogen dioxide, ozone, carbon monoxide, and volatile organic compounds.

## Regression Analysis

**Table 3:** Result of Regression Analysis

| Coefficients[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 1.806 | .484 | | 3.732 | .001 |
| | Environmental Factors | -.238 | .148 | -.235 | -1.611 | .114 |
| | Climate change | .018 | .178 | .015 | .102 | .919 |
| | Air Quality | .115 | .171 | .096 | .675 | .503 |
| a. Dependent Variable: Equine Health | | | | | | |

The result shown in Table 3 presents the regression analysis of the dependent and independent variables. The result shows that the unstandardized coefficient includes the beta value and its standard error. The result is that the t-statistic and significance values for each variable are obtained. The environmental factors show a t-statistic of -1.611 and a p-value of 0.114, indicating a negative association between environmental factors and equine health ($p < 0.115$). The climate change coefficient shows a t-statistic of 0.102 and a p-value of 0.919, indicating a positive association and a 91% significant regression effect between equine health and climate change. The final variable is air quality, which has a 67% positive effect on equine health. The results also indicate a significant 50% association between air quality and equine health.

However, during prolonged dry spells, dust levels in the air are higher, and respiratory complications worsen. Long-lasting or repeated exposure to such pollutants dilates the airways, impairs mucociliary clearance, and increases the risk of developing respiratory diseases such as Recurrent Airways Obstruction (RAO), Inflammatory Airway Disease (IAD), and asthma-like symptoms. Although the effects of wildfire smoke are observed several days or even weeks after the event, even short-term exposure to smoke, characterised by large areas of concentrated particles, can impair the sport horse's lung function, weaken immunity, and reduce performance. Climate change and air quality pose more risks. The positive effect of increased temperatures and extended drought is the production of wildfires, which generate a dense layer of particulate matter and other harmful chemicals that travel long distances even after combustion.

During wildfire season, equestrian facilities located several kilometres away experience significant fluctuations in ambient conditions, resulting in the cancellation of training and movement activities and increased veterinary treatment. During a drought, it can increase dust concentrations, leading to long-term respiratory problems. All these environmental pressures can initiate systemic inflammation, augment oxidative stress, and increase cortisol levels, ultimately affecting overall health and behaviour. Changes in the environment are also associated with nutritional and gastrointestinal health (Figure 3).

**Figure 3:** Wildfire Season

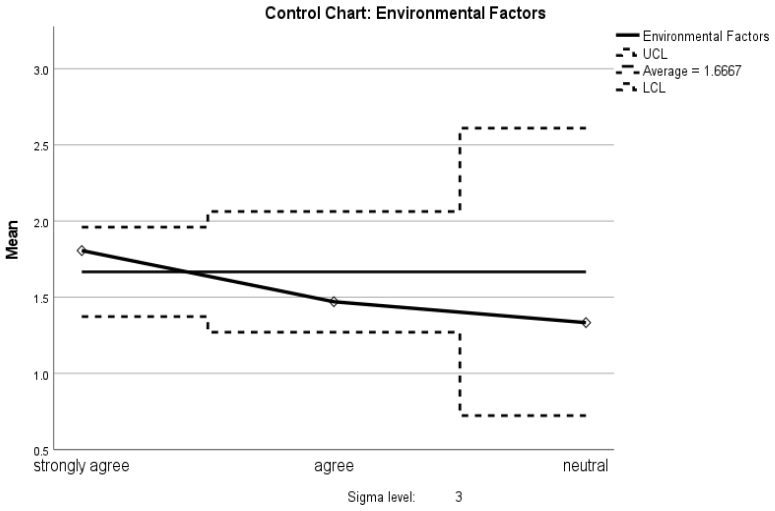


**Figure 4:** Control Chart: Environmental Factors

The above graph, shown in Figure 4, presents the control chart between environmental factors and equine health. The overall average rate of 1.6667 shows a positive and significant link between them.

## Applications

The implications of environmental alterations (changes in climate, declining quality of air) on equine health go significantly deeper than can be understood in academic circles; they have practical implications in veterinary care, stable management, training regimes, nutrition strategies, and policy development. The experience obtained during the study of the effects of climate change and air pollution can contribute to the work of horse owners, trainers, veterinarians, and policymakers to make changes that enhance the welfare of the horse population, its performance, and health over time. In this section, the author explains how the results of such research could be converted into practical use in most fields of study.

1. Stable and Facility Management: Among the closest applications of this study is on the design and management of stables and horse facilities. Since respiratory and thermoregulatory stresses among horses are heightened by heat conditions and poor air quality, the architecture of the stables could be modified to mitigate them. As an example, good ventilation systems that permit the flow of air but block the movement of particulate matter can significantly reduce Recurrent Airway Obstruction (RAO) and other respiratory diseases. High-efficiency particulate air (HEPA) filters can also be used to protect horses during the season of wildfire smoke or severe urban pollution. Another important factor is thermos control. Having heat-mitigating measures like insulated roofs, shades, misting sprinklers, and evaporative coolers can also be used to ensure an optimal body temperature in the event of a heatwave. Horses competing in sport or horses at work are the most vulnerable to heat stress, and hence, integration of these facility additions guarantees welfare and performance. In addition, heavy flooring and drainage mechanisms that prevent cases of muddy floors help mitigate hoof related diseases like thrush or abscesses, which can be prevalent during heavy rains and flood seasons.

2. Veterinary Practices and Preventive Health Care: The findings of the research on environmental stress factors provide veterinarians with the information necessary to design the preventive health care routine based on climatic and air quality factors. As an illustration, the veterinarians will be able to create vaccination schedules, deworming plans, and respiratory plans that take into consideration the seasonal exposure to a higher risk of infection due to warmer weather or larger populations of vectors. When there is a wildfire season or dust storm, veterinarians can recommend relocating temporarily, using air filtration masks on horses, or modifying exercise habits so that respiratory exposure does not occur. Also, the signs of heat stress, oxidative injury, and respiratory inflammation can be analysed by veterinarians to identify the early signs of environmental stress before clinical manifestations can occur. This is proactive and encourages early diagnosis, reduces the severity of diseases, and does not cause any decline in performance. Telemedicine services in veterinary care can be abused even in extreme weather conditions where it isn't easy to visit the horses on-site, so it is possible to monitor the health of the horse remotely.

3. Training: Environmental conditions also have a direct correlation to equine performance, and the findings of the research are of particular significance to working and competition horses. Training schemes, the intensity level, and rest can be informed using climate and air quality data. In case, one can mention that horses should not be overexercised when it is hot or when the concentration of the particulate matter is high. Training may be done when the weather is colder, or it can be done in an indoor setting with air filtering devices. In addition, wearable devices can be used to give real-time feedback on physiological stress (e.g., heart rate monitors, thermometers, GPS trackers, etc.), which allows trainers to modify the intensity of exercise and rest periods

dynamically. Implementing environmental monitoring processes, such as temperature, humidity, and air quality sensors in the training regimens, is a prospective application of the research results that can protect the health of equines and maintain optimal performance.

4. Nutrition: Nutrition has been shown to be vital to the prevention and management of urinary tract infection, as well as the treatment of acute urinary tract infection. The environmental condition highly influences equine dietary requirements. The stress of heat augments water and electrolyte loss, and inadequate air quality may reduce feed consumption because of breathing anguish. Studies have been used to come up with nutrition programs that counter the environmental stress factors. As an example, dehydration and energy maintenance, as well as gastrointestinal disorders, such as colic, are prevented by the administration of electrolyte supplements, regulation of feeding times, and the use of high-quality and low-dust forage. The regulations of pasture access may be considered as climate-adaptive feeding. Horses can be fed regulated diets in the stables in cases of high pollen or dust, and rotation grazing can reduce exposure to environmental toxins or invasive plant species that flourish in the changing climatic conditions. These nutritional habits not only enhance health but also promote performance, immunological response, and recovery.

5. Environmental Surveillance and Early Alert Systems: The study on the effects of climate and air quality offers a model for developing monitoring systems, which can cushion equine populations. The air quality indicators, sensors of the presence of PMs and meteorological data can be incorporated into the horse owner and management decision-making platforms. An early warning can alert the caretakers to danger like wildfire smoke, heatwave, dust storms, etc., and necessary action will be provided. Moreover, regional environmental surveillance systems could be utilised to augment veterinary public health services by revealing those intervals when there is an increased risk of disease through the proliferation of vectors or the endurance of pathogens through warm and moist conditions. Increased preparedness and coordinated intervention to lower the frequency of environmentally induced morbidity among equine populations is enhanced by information-based warning.

6. Policy and Regulatory Applications: Research on the environmental stressors in horses can have an impact on policy implementation at local, regional and national levels. The regulatory systems can be designed to guarantee minimum requirements on consistent ventilation, shading facilities and emergency preparedness in the event of extreme weather conditions. Sustainable land use policies can also promote sustainable land use practice that ensures that pasture quality is maintained and that exposure to environmental contaminants is reduced. Moreover, the scientific evidence can be used to formulate recommendations regarding competition and transportation under severe environmental conditions. As an example, equestrian federations or authorities in horse racing are able to impose a restriction on training or racing in seasons when the weather is hot or polluted to protect as well as to maintain fairness in competitions. These are some of the policy applications that demonstrate the potential of scientific research to deliver systemic benefits in the equestrian industry.

7. Technology-Based Solutions: New technologies introduce innovative ways of reducing environmental costs. The air purifiers, smart stables, wearable sensors, and automated climatic control equipment are now more accessible and can be incorporated into the equestrian care plans. Environmental data, horse health indicators and training plans can be concentrated with the help of mobile applications and cloud-based platforms to enable caregivers to make decisions based on evidence in real time.

## Discussion

The results of this research depict the diverse effects of the environmental conditions, especially climate change and air quality, on the health of equines, emphasising a complex interconnection between physiological, behavioural, and environmental determinants of welfare. Climate change and decreasing air quality do not operate independently; they are synergistic to have an impact on horse management, health, and performance needs. It is essential to know these relationships that would help to formulate evidence-based means to reduce health risks and enhance equine welfare. Heat stress is an important concern that occurs when there is climate change. High temperatures and high humidity influence thermoregulation, leading to dehydration, electrolyte disturbances and loss of exercise tolerance. All these physiological stressors are aggravated when the horses are also exposed to bad air. Particulate matter, ozone, and nitrogen oxides increase the load on the respiratory system, decreasing oxygen availability and exacerbating cardiovascular and pulmonary stress on exposure to heat. The cumulative effect of this necessitates the need for combined management strategies that tackle the stresses of temperature as well as air quality, at the same time. The health of the respiratory system is very susceptible to environmental disturbances. The research supplements the available literature that indicates that prolonged exposures to pollutants and allergens can cause Recurrent Airway Obstruction (RAO), Inflammatory Airway Disease (IAD), as well as other lung disorders. Respiratory care is made more difficult by the seasonal phenomenon of wildfire smoke in dry seasons or the rising pollen in summer. It has been found that behavioural studies detect that horses restrict external activity and change grazing behaviour in response to environmental stress, which can affect the feed intake, energy balance and performance. These behavioural adjustments suggest that environmental stressors not only have an effect on the physiological health, but also on day-to-day activities and welfare outcomes. The effects of climate change on disease ecology also exist. The increase in temperature and altered weather patterns extend the geographic and active ranges of disease vectors (e.g. mosquitoes and

ticks), making disease vectors like the West Nile virus and African horse sickness more likely. Alterations in the quality of pastures and the composition of plants can introduce toxins in the ration, whereas dry weather leads to increased exposure to dust and worsens breathing problems. These data indicate that adaptive health management methods, such as the control of vectors, pasture planning, and nutrition optimisation, are needed. In a management dimension, the subject highlights the importance of initiatives. Facilities, stable buildings, ventilation and air purification are instrumental in the reduction of stress levels on the environment, whereas diet and hydration methods benefit in the reversal of physiological impediments. The early-warning systems and continuous monitoring of the environmental factors will help the caretakers to act in time to avoid dangerous situations. Some of the policy implications are the establishment of standards of equine welfare in unsuitable weather conditions and poor air quality, and the regulation of training, competition, and transportation during critical periods. Finally, the research indicates that environmental forces are correlated as equine health drivers. The physiological functioning, behaviour, and disease susceptibility are influenced by climate change and air quality issues, which necessitate an evidence-based approach to equine care that is integrated.

## Conclusion

This paper demonstrates that the environmental conditions, especially climate change and air quality, have a significant impact on equine health, welfare, and performance, which is multifaceted. It has been revealed that horses are especially sensitive to changes in temperature, humidity, precipitation, and airborne contaminants, and physiological, behavioural, and immunological responses are signs of acute and chronic stress. Climate change causes heat stress, alters the pasture quality, alters the dynamics of vectors and diseases and raises extreme weather conditions. At the same time, low quality of air, such as the high concentration of particulate matter, ozone, and nitrogen oxides, worsens respiratory diseases, reduces athletic performance, and deteriorates the general welfare. These stresses tend to be synergistic as they increase their effects and require a combined strategy in equine management. Environmental stress leads to physiological changes with consequences. The exposure of horses to high temperatures and humidity results in dehydration, electrolyte imbalance, and ineffective thermoregulatory response, and the poor air quality leads to inflammatory changes, airway congestion and respiratory disease. The changes in behaviour, such as grazing, resting and activity patterns, reflect behavioural adaptations with the aim of reducing environmental stress, but the changes can also influence the outcome of nutrition, growth and performance. In addition, the ecological changes in disease caused by climate and changes in the forage structure predispose to the development of vector-borne infections, parasite attacks, and dietary toxicity, which pose other health-related risks that need to be proactively controlled at the veterinarian level and adapted to managerial changes. In practical terms, this study will emphasise the importance of the application of evidence-based therapies. The enhancement of stable design, such as effective ventilation, filtration, and heat mitigation systems, is crucial to the maintenance of environmental control. The nutrition and hydration regimes should be modified to align with the changing physiological needs, and the training and activity programs should take into consideration the differences in terms of temperature and air quality between seasons and even days. Real-time environmental surveillance, predictive modelling, and early-warning systems increase preparedness and real-time responses to dangerous situations to reduce morbidity and mortality. Moreover, educational and sensitisation programs to horse owners, trainers and veterinarians are essential to allow scientific knowledge to be translated into sound care practices. The potential implications of this study are the interaction of equine health with environmental sustainability and policy. Having climate resilience as part of equine management strategies, establishing standards of well-being in adversarial contexts, and adopting technological innovations to monitor and prevent are all crucial towards sustaining the population of horses in the face of constant environmental fluctuation. It is essential to have collaboration among the veterinarians, researchers, policymakers, and horse owners to develop versatile strategies that enhance long-term welfare, performance, and sustainability in the equine industry. To sum up, the issues of climate change and the reduction of air quality are interrelated factors that have a severe negative impact on equine health. This research paper presents the necessity of comprehensive, evidence-based methods that integrate physiological, behavioural, and environmental elements. Through the integration of scientific research and practical management action, it is possible to reduce or mitigate the negative effects of environmental stresses, enhance equine welfare and survive in an ever-changing, less predictable and more challenging environment. Subsequent efforts are still needed to optimise adaptation strategies, keep track of new environmental issues and integrate interdisciplinary expertise that can serve the good health and well-being of equine populations across the world.

## Recommendations

The results of the overall research are as follows: it is possible to suggest numerous practical and strategic recommendations that can be made to decrease the significance of climate change and air pollution on equine health. These suggestions will help improve the welfare of horses, prevent diseases, and preserve performance & sustainable, as well as adaptive management practices throughout the equine industry.

1. Systems of Environmental Checks and Early-Warnings: To prevent and control the situation, it is important to monitor the resident air quality index and temperature on a systematic basis. Heatwaves, dust storms, or wildfire smoke will be rapidly distinguished by installing temperature, humidity, and air quality sensors in stables,

paddocks, and training areas that will enable the caretaker to respond fast. The combination of real-time monitoring, prediction models, and alarm systems could allow early interventions, which may include changing the training time, giving extra fluids, or temporarily moving horses to safer places.

2. Stable Design and Facility Management: Stables and sheds must be designed so that they make the most of the air flowing through the structures, the air circulation, and the temperature. High-efficiency particulate air (HEPA) filters, shade structures, insulated roofing, and evaporative cooling systems can significantly reduce stress in the environment on horses. Good drainage and floors reduce the issues of hooves, and frequent cleaning prevents the presence of dust and mould that encourages lung infections.

3. Nutrition and Hydration Plans: Feeding plans ought to change in consideration of environmental difficulties. The horses need extra water and electrolytes in heat or poor air quality to avoid dehydration and metabolic imbalance, and high-quality, low-dust feed must be prioritised and grazing schedules avoided when there is a lot of exposure to pollen, dust, or pollution. Nutrition plans should also consider climatic changes in the quality and availability of pastures.

4. Veterinary and Preventive Care: Veterinary procedures must involve periodic checkups on respiratory, cardiovascular and thermal conditions. Seasonal changes should be made in vaccinations, deworming, and disease surveillance to consider the threat of vector-borne disease. Early detection of the effects of environmental stress can be achieved through non-invasive measurements of stress biomarkers, lung and hydration status, to initiate timely intervention.

5. Training and Exercise Management: The exercise plans must be changed with respect to the temperature, humidity and quality of air. Horses are not supposed to be highly active when the weather and the air are hot and unhealthy. Fitness can be maintained in indoor training facilities with air filtration or outdoor facilities where there is a shield over the outdoor area. When there are events of harsh weather, recovery periods are supposed to be augmented to avoid fatigue and health deterioration.

6. Policy and Education: The institutions and the regions should adopt guidelines and regulations that are guaranteed to promote safe practices of horses in the harsh environmental conditions. The owners, trainers, and caretakers of horses must be informed about threats concerning the climate, respirators, mitigation measures against heat, and emergency preparedness. The transfer of knowledge and awareness creation will make evidence-based practices a regular practice.

7. Research and Technological Integration: It is advised to continue the research on climate resilience, air filtration technology, and predictive modelling. Smartphone applications, wearable sensors and cloud-based monitoring systems will enhance decision-making and adaptive management. Their implementation in the everyday routine facilitates the long-term health outcomes and makes the horse sector ready for the future environmental challenges.

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