



Climate Change and Its Impacts on Mulberry (*Morus* spp.) Cultivation: Challenges and Future Strategies

*M. Parasuramudu, M. Venkatesh Prasad, K. Nandhini and M.V. Tarun Kumar
Post Graduate, Department of Sericulture, Sri Krishna Devaraya University,
Anantapur-515003, Andhra Pradesh, India

*Corresponding Author's email: parasuram723b@gmail.com

Mulberry (*Morus* spp.), a perennial tree species, is the foundation of the sericulture industry as its leaves are the exclusive food source for the domesticated silkworm, *Bombyx mori*. For centuries, mulberry cultivation has sustained silk production and provided livelihood support to millions of rural households across Asia, particularly in China, India, Thailand, and several emerging sericulture regions in Africa and Latin America. Beyond its economic significance, mulberry cultivation contributes to soil conservation, carbon sequestration, and biodiversity enhancement through its integration in agroforestry systems. Despite its resilience as a hardy tree species, mulberry is highly sensitive to environmental conditions, and its productivity is directly shaped by climatic factors such as temperature, rainfall, soil moisture, and seasonal variability. As climate change accelerates, the stability of mulberry cultivation has come under increasing threat, jeopardizing not only silk production but also rural economies that depend on this crop.

The ongoing changes in global climate patterns—rising average temperatures, erratic rainfall distribution, increased frequency of droughts and floods, and the emergence of new pest and disease complexes—pose unprecedented challenges for mulberry farmers. These stress factors affect the physiological functions of the mulberry plant, altering its growth patterns, nutrient composition, and leaf yield. Since the quality of mulberry leaves directly determines silkworm health and cocoon production, climate-induced stress on mulberry inevitably reduces the sustainability of the entire sericulture sector. Recognizing these challenges, researchers, policymakers, and farmers have turned their attention toward building climate-resilient mulberry cultivation systems through genetic improvements, sustainable agricultural practices, and innovative adaptation strategies.

This article examines in detail how climate change impacts mulberry cultivation, analysing the specific stress factors, physiological consequences, ecological disruptions, and socio-economic implications. It further explores adaptation strategies, ranging from genetic improvements to agronomic innovations, supported by real-world case studies and policy perspectives. By focusing exclusively on mulberry, the aim is to highlight its centrality to sericulture and emphasize the urgent need for climate-resilient interventions in this critical sector.

Climatic Requirements of Mulberry and Its Sensitivity

Mulberry is a versatile plant capable of growing in diverse agro-climatic regions, from temperate zones in East Asia to tropical and subtropical environments in South and Southeast Asia. However, optimal productivity requires specific climatic conditions. The ideal temperature range for mulberry growth is between 20°C and 30°C, with moderate humidity and well-distributed annual rainfall ranging from 600 to 2,500 mm. Mulberry thrives in well-drained loamy soils rich in organic matter, though it can adapt to sandy and clay soils if managed properly. Seasonal changes significantly influence mulberry productivity, with

spring and early monsoon seasons typically producing the highest leaf yields due to favourable moisture and temperature conditions.

Despite its adaptability, mulberry is highly vulnerable to climatic extremes. Temperature fluctuations beyond the optimal range, prolonged droughts, excessive rainfall, and waterlogging conditions all negatively affect leaf yield and quality. Unlike annual crops that can be replanted quickly, mulberry is a perennial plantation crop with long-term investment requirements. Thus, any climate-induced stress not only reduces immediate productivity but also has lasting impacts on plant health and subsequent yields. Moreover, the nutritional composition of mulberry leaves, particularly protein and carbohydrate content, is sensitive to environmental changes. Leaves produced under stress conditions often have higher fiber and lignin content, which reduces their digestibility and overall suitability as silkworm feed. This dual vulnerability—affecting both yield and quality—makes mulberry highly susceptible to climate change and a central concern for sustainable sericulture.

Climate Change Impacts on Mulberry

Rising Temperatures and Heat Stress

One of the most evident manifestations of climate change is the steady rise in average global temperatures, accompanied by more frequent heat waves. For mulberry, elevated temperatures disrupt physiological processes such as photosynthesis, respiration, and nutrient assimilation. Studies conducted in India and China have shown that heat stress reduces chlorophyll content in mulberry leaves, leading to a decline in photosynthetic efficiency. This reduction translates into slower growth rates, smaller leaf sizes, and lower biomass accumulation.

Heat stress also alters the biochemical composition of mulberry leaves. Under high temperature, leaves tend to accumulate stress metabolites such as proline and soluble sugars, while protein content decreases. Since protein is the most critical nutrient for silkworm development, a decline in leaf protein content under heat stress directly undermines the value of mulberry as a feed crop. In addition, excessive heat accelerates evapotranspiration, increasing water requirements at precisely the time when droughts are becoming more common.

Altered Rainfall Patterns and Water Stress

Equally significant as temperature rise is the disruption of rainfall patterns. Climate change has increased both the intensity and variability of rainfall, resulting in prolonged droughts in some areas and excessive floods in others. Mulberry, being a deep-rooted perennial, can withstand short-term water shortages; however, prolonged droughts severely reduce leaf yield and alter leaf composition. Under drought conditions, mulberry leaves show reduced nitrogen content, increased fiber, and lower palatability for silkworms.

On the other hand, excessive rainfall and waterlogging are equally damaging. When soils remain saturated, mulberry roots suffer from oxygen deficiency, leading to root rot, stunted growth, and reduced leaf production. In India, the increasing irregularity of monsoon rainfall has created similar challenges, with dry spells followed by heavy downpours damaging both rain-fed and irrigated mulberry systems.

Extreme Weather Events

Beyond gradual climatic changes, extreme events such as cyclones, hailstorms, and unseasonal rains pose acute risks to mulberry cultivation. Coastal regions of India, particularly Andhra Pradesh and Odisha, have reported large-scale damage to mulberry plantations during cyclonic storms, where high winds uproot trees and excessive saltwater intrusion damages soils. In semi-arid areas, sudden hailstorms have been known to strip mulberry trees of their leaves, destroying months of effort in a single day. Such unpredictable events not only disrupt leaf availability but also discourage farmers from investing in mulberry cultivation, thereby threatening the continuity of sericulture.

Pest and Disease Outbreaks

Climate change has also altered the ecology of pests and diseases affecting mulberry. Warmer temperatures and increased humidity accelerate the reproduction cycles of insect pests such

as leaf rollers, thrips, and mealybugs, which attack mulberry leaves. Similarly, fungal pathogens such as leaf spot and bacterial blight have become more prevalent under changing climatic conditions. These ecological disruptions further weaken mulberry plantations and reduce leaf quality, compounding the effects of abiotic stress factors like heat and drought.

Physiological and Biochemical Responses of Mulberry to Climate Stress

Mulberry responds to climate stress at multiple physiological and biochemical levels. Drought stress induces stomatal closure, reducing photosynthetic activity and carbohydrate accumulation. Prolonged water scarcity leads to leaf wilting, reduced leaf area, and early senescence, all of which contribute to lower yields. On a biochemical level, stress conditions increase the production of reactive oxygen species (ROS), which damage cellular structures unless neutralized by antioxidant enzymes such as catalase and peroxidase. Research has shown that mulberry varieties with higher antioxidant capacity exhibit greater tolerance to stress conditions, making this trait a potential marker for breeding climate-resilient cultivars.

Nutritional changes are another critical response to climate stress. Under drought or heat stress, mulberry leaves exhibit lower crude protein levels and increased fiber content, reducing their digestibility for silkworms. Waterlogging conditions, by contrast, result in nutrient leaching from soils and reduced nitrogen uptake, further lowering protein content. Such biochemical shifts highlight the indirect pathways through which climate change affects the broader sericulture industry by compromising leaf quality, even if yields remain relatively stable.

Socio-Economic Implications

The vulnerability of mulberry cultivation to climate change extends beyond biology and ecology into the socio-economic fabric of rural communities. In India alone, more than **9.73 million people** are engaged in sericulture, many of them small-scale farmers who rely heavily on mulberry cultivation for their income. Declines in mulberry productivity directly reduce household earnings, making farming families more vulnerable to poverty and migration pressures.

Women play a particularly important role in mulberry farming, often handling tasks such as leaf plucking, irrigation, and intercultural operations. Climate stress disproportionately affects women farmers, as they must balance declining agricultural returns with household responsibilities. In some farmers have reported shifting away from sericulture toward less climate-sensitive crops, despite the long-standing cultural and economic importance of silk in these areas.

Moreover, climate-related disruptions in mulberry supply chain stability lead to price volatility in cocoon markets, further discouraging farmer participation. This creates a vicious cycle, as declining mulberry production reduces silkworm rearing opportunities, which in turn weakens the entire sericulture sector. Hence, addressing climate challenges in mulberry cultivation is not merely an agricultural necessity but also a socio-economic imperative.

Adaptation Strategies for Climate-Resilient Mulberry Cultivation

To sustain mulberry cultivation in the face of climate change, multiple adaptation strategies are being explored and implemented. Genetic improvement, agronomic practices, agro ecological integration, and technological innovations all play crucial roles in building resilience.

Genetic Improvement

Breeding mulberry varieties tolerant to drought, flooding, and heat stress is a long-term solution. Advances in molecular breeding and marker-assisted selection are accelerating the development of stress-resilient cultivars. Genetic studies are being used to identify heat-tolerant genotypes with improved antioxidant activity, while genome editing technologies hold promise for tailoring mulberry traits to specific environmental challenges.

Agronomic and Soil-Water Management

Improved agricultural practices offer immediate resilience benefits. Mulching with organic matter conserves soil moisture during dry periods, while drip irrigation optimizes water use efficiency. In flood-prone areas, raised bed cultivation prevents root damage, and contour bunding helps manage runoff in hilly terrains. Integrated nutrient management, combining organic manures with mineral fertilizers, enhances soil fertility and supports mulberry resilience under stress conditions.

Agroforestry and Ecological Approaches

Integrating mulberry into agroforestry systems provides microclimatic regulation and additional sources of income for farmers. Intercropping mulberry with legumes improves soil nitrogen levels, while shelterbelts reduce wind damage and temperature extremes. Such ecological approaches not only buffer mulberry against climate extremes but also improve biodiversity and sustainability of farming systems.

Technology and Climate Services

Digital technologies and climate services are increasingly being adopted in mulberry farming. Mobile applications providing weather forecasts and advisory services enable farmers to plan irrigation and pest management more effectively. Remote sensing and GIS tools assist in identifying vulnerable areas and guiding plantation planning. Climate modeling helps forecast long-term trends, informing breeding and policy decisions.

Policy and Institutional Support

Policy interventions are essential to support farmer adaptation. Subsidies for drip irrigation systems, crop insurance schemes for mulberry farmers, and financial assistance for adopting climate-smart practices can ease the burden of climate stress. Extension services that disseminate knowledge about stress-tolerant cultivars and sustainable practices are equally critical. International organizations such as the International Sericulture Commission play a key role in facilitating cross-country knowledge exchange and promoting global action on climate resilience in sericulture.

Future Outlook

The future of mulberry cultivation under climate change depends on the integration of traditional farming knowledge with modern scientific innovations. Breeding climate-resilient mulberry varieties, improving soil and water management practices, and adopting agro ecological approaches will be critical. Equally important will be policy frameworks that provide economic safety nets for farmers and encourage adoption of climate-smart practices.

Mulberry also holds untapped potential in climate mitigation efforts. As a perennial tree, it contributes to carbon sequestration and soil conservation. Integrating mulberry into agroforestry systems not only supports sericulture but also enhances ecosystem services, aligning with broader goals of sustainable agriculture and climate adaptation.

Conclusion

Mulberry cultivation stands at the frontline of climate change impacts, with rising temperatures, erratic rainfall, extreme weather events, and ecological disruptions threatening its productivity and sustainability. These challenges extend beyond agriculture, affecting the socio-economic well-being of millions of farmers whose livelihoods depend on sericulture. However, a combination of genetic improvements, adaptive agronomic practices, ecological approaches, technological innovations, and supportive policies can build resilience in mulberry cultivation. By safeguarding mulberry, we safeguard the foundation of sericulture, ensuring the continued availability of silk as both an economic product and a cultural heritage. The path forward lies in coordinated efforts that bring together science, policy, and community action to secure the future of mulberry cultivation in a changing climate.

References

1. Datta, R. K., & Nanavaty, M. (2020). *Global Silk Industry and Sericulture Development*. Springer.

2. Dandin, S. B., Jayaswal, J., & Giridhar, K. (2014). *Handbook of Sericulture: Technologies and Management*. Central Silk Board, India.
3. Kaewkorm, S., Chansongkrow, P., & Sontua, S. (2020). Climate resilience in mulberry cultivation under tropical conditions. *Journal of Sericulture Research*, 54(2), 101–115.
4. Kumar, R., Meena, R., & Sharma, D. (2019). Climate change impacts on mulberry and sericulture: A review. *Indian Journal of Agricultural Sciences*, 89(7), 1120–1127.
5. Kumari, P., & Sekhar, S. (2022). Mulberry responses to climate variability: Physiological and agronomic perspectives. *Agricultural Reviews*, 43(3), 210–220.
6. Ravindra, B., Raghunath, M., & Reddy, Y. (2018). Climate variability and its effects on mulberry production in South India. *Sericologia*, 58(1), 45–56.
7. Sharma, A., Singh, V., & Rahman, M. (2021). Invasive species and climate change impacts on mulberry ecosystems. *Environmental Biology and Climate Journal*, 6(4), 55–70.
8. Singh, G., & Chakraborty, D. (2021). Socio-economic perspectives of climate change and sericulture sustainability. *Asian Journal of Rural Development*, 11(1), 1–12.
9. Srivastava, K., Banerjee, S., & Patel, P. (2017). Physiological responses of mulberry under water stress conditions. *Plant Stress Biology*, 9(2), 89–98.