Adapting Hazelnut Cultivation to a Changing Climate

Sheryl Loke[1]

In 2009, the Bhutanese government approved hazelnut production as an agribusiness to integrate sustainable agriculture with community development, and to address the pressing challenges of climate change. The country's first fully foreign direct investment company, Mountain Hazelnuts, aimed to provide long-term income for vulnerable rural communities, where approximately 70% of the population relies on subsistence farming (Mirza and Loke, 2020).

Hazelnuts were introduced as a viable cash crop, promoting environmental restoration and resilience. More than one million hazelnut trees were planted on fallow and degraded lands, thereby contributing to biodiversity and carbon sequestration efforts in Bhutan's fragile ecosystems (Hoyt and Lee, 2011).

In an economic context where farming is hindered by small landholdings and difficult terrains, the project engages more than 8,000 smallholder families, providing training, agricultural inputs, and support to enhance productivity and livelihoods (Mirza and Loke, 2020).

Hazelnut cultivation is ideally suited to the Himalayan foothills of Bhutan. Mountain Hazelnuts saw itself strategically positioned to capitalise on a unique market opportunity in the hazelnut industry, which offers significant revenue earning potential internationally. Hazelnuts are one of the top three tree nut crops globally, with a market value exceeding US$ 9 billion.

However, supply is heavily concentrated, with Turkey producing 70% of the world's hazelnuts, posing unacceptable agro-ecological and political risks for major hazelnut processors. With annual market growth averaging five percent, there is ample demand for Bhutan's high-value, low-volume production, which could eventually represent one percent or more of the global supply.

1 Sheryl Loke leads the development and execution of strategic initiatives at Mountain Hazelnuts to drive growth.

By providing access to sustainable agricultural practices, the project aims to empower farmers, especially women, who make up 43% of Bhutan's hazelnut growers. In at least eight dzongkhags (districts), women outnumber men in hazelnut cultivation. This support also strengthens community resilience in an increasingly unpredictable climate.

The environmental benefits of hazelnut cultivation align with Bhutan's national goals for sustainable development and climate adaptation. Hazelnut cultivation contributes significantly to soil health, erosion control and the restoration of degraded lands, addressing Bhutan's vulnerabilities to climate change, such as rising temperatures and water scarcity (Dalton, 2020).

Hazelnut cultivation, however, faces challenges related to climate change and environmental uncertainties that could impact production capacity and community commitments. The company, therefore, is adopting innovative approaches to climate resilience (Rabten, 2024) to be a crucial player in the intersection of economic growth, environmental stewardship, and social equity in Bhutan.

The Economic Context

Bhutan's economy is largely based on agriculture, forestry, tourism and hydroelectric power, with 70% of the population living in rural areas and relying on subsistence farming for their livelihoods. On average, smallholder farm sizes range from half to two acres, and much of the terrain is unsuitable for traditional crops, due to steep gradients and harsh climates, resulting in only eight percent of the land being cultivable (Mirza and Loke, 2020).

Farmers primarily grow maize, rice and vegetables, which often yield insufficient income. This economic reality is compounded by high transport costs and limited access to markets, making it difficult for rural households to thrive economically (IDH, n.d.). Integrating smallholder families into its hazelnut production system not only provides farmers with hazelnut trees and agricultural inputs but also offers training in good agricultural practices.

The Environmental Context

The environmental benefits of hazelnut cultivation are significant, particularly in the context of climate change and land degradation. Bhutan's mid-elevation areas (approximately 1,600-3,000 metres) provide optimal conditions for hazelnut cultivation because of consistent annual monsoon rains and cool winters that promote tree dormancy (IFC, 2021).

The Ministry of Agriculture and Forests recognised the potential of hazelnuts as early as the 1990s, establishing trial orchards that demonstrated the viability of this crop in Bhutan's unique climate (IFC, 2021). By planting over one million hazelnut trees on fallow or degraded land, the project contributes to land restoration efforts. This approach not only avoids further degradation of forested areas but also promotes biodiversity and enhances the resilience of ecosystems against climate change (Hoyt and Lee, 2011). The company's operations align with national goals for sustainable development and environmental conservation, making it a vital player in Bhutan's efforts to combat climate change.

Climate Vulnerability in Bhutan

Bhutan is highly vulnerable to the impacts of climate change, which poses significant threats to its environment and economy. The country faces challenges such as rising temperatures, water scarcity and increased incidents of landslides due to glacial lake bursts as ice continues to melt (Dalton, 2020). These climatic changes not only affect agricultural productivity but also threaten the livelihoods of rural communities that rely heavily on subsistence farming. The introduction of climate-resilient farming techniques, such as improved irrigation systems and water management practices, is crucial for sustaining agricultural productivity amidst changing climatic conditions.

Bhutan launched its first National Adaptation Plan in 2023, which emphasises the importance of sustainable agricultural practices. As part of this initiative, the government is providing technical assistance to farmers, including training in climate-resilient farming techniques, pest management, and crop management. This multifaceted approach not only aims to increase crop yields but also seeks to empower farmers, particularly

women. With such training and capacity building initiatives, Bhutan hopes to improve food security and economic resilience.

Economic Impact

Hazelnut cultivation has the potential to help address climate change through sustainable agriculture in Bhutan. Through current and planned plantings across the country, hazelnut trees will sequester a total of 500,000 tonnes of CO2e over the productive lifetime of the trees. Hazelnut orchards play a crucial role in preventing soil erosion, safeguarding watersheds, and improving soil quality, ultimately aiding in carbon sequestration and climate change mitigation efforts (ADB, n.d.).

Mountain Hazelnuts delivers seedlings to farmers with no upfront payment or financial commitment. It supplies all the necessary inputs to cultivate hazelnuts, ranging from hazelnut saplings, tools, training, technical expertise, operations supervision, and an overarching support structure. It also guarantees a minimum floor price for the purchase of the hazelnut harvest at a fair price established with the Ministry of Agriculture and Livestock and processes the crop for export sale through its international marketing network. The company has also pledged to share 10 percent of its annual profits via a grower profit-sharing pool account distributed pro-rata to all active grower partners.

This fund is expected to begin in 2029 when the restructured company anticipates being cash-flow positive. Increased household-level income is a key factor empowering rural communities to implement farm-level actions for climate resilience (e.g. irrigation systems).

Soil Health and Erosion Control

One of the primary environmental benefits of hazelnut cultivation is its positive impact on soil health. Planted on contour rows, beneficial terracing will result from the management and harvesting of the trees over time. In addition, hazelnut trees possess extensive root systems that bind the surrounding soil, improve water drainage, and reduce runoff.

These trees are naturally suited to no-till farming methods, which means that the soil remains covered for longer periods compared to annual crops. This

is particularly crucial during summer months when erosion rates typically increase due to rain and wind. By planting hazelnuts on degraded or fallow land, Mountain Hazelnuts help restore soil quality, reduce landslide risks, and enhance watershed stability (Department of Tourism, 2023).

Carbon Sequestration

The cultivation of hazelnuts in Bhutan is associated with the storage of approximately half a million tonnes of CO2 significantly contributing to climate change mitigation. Compared with traditional annual crops, perennial hazelnuts require less water and are better at storing carbon. As a climate-resilient crop, hazelnuts are capable of growing under moderate climatic conditions, allowing them to thrive in Bhutan's mountainous regions while offering significant ecological benefits (Mirza and Loke, 2020).

Climatic Challenges of Hazelnut Cultivation

The original variety mix was selected based on the evidence that was available on the ground, including historical climatic data from the available long-term stations, biological indicators based on other fruit trees/oaks, and the confirmatory research station plantings in the Research and Development Centre, Yusipang.

On the ground, company-managed variety trials were not implemented before rapid scaling, which in hindsight - especially given the subsequent challenges encountered - should have been performed. The first challenge was that polleniser varieties could not be produced in significant numbers in the tissue culture lab. This meant delayed plantings of pollenisers in low numbers, guaranteeing low hazelnut yields for an extended period, which masked potential underlying issues.

The company commenced grafting in 2019 to solve the polleniser issue. This grafting of pollenisers did address fruiting for plantings above 2,400m elevation in line with the original variety mix, but not for plantings below 2,400m.

In 2021, inconsistent flowering of the main production variety below 2,400m due to a warmer winter became very obvious once the polleniser

constraint was removed. This increasing long-term climate change risk prompted the move to production varieties that require lower chill hours (varieties which by then were already proven in Bhutan). The company has built on the learning and observations of the last decade and now has a proven climate resilient varietal mix validated on the ground by third-party agronomic experts and growing harvests.

It is also forming a Scientific Council, with a mix of international hazelnut experts and national horticulturalists, to ensure that there is a robust body of hazelnut knowledge in the country for the long-term success of hazelnut cultivation.

Climate change poses a significant threat to hazelnut production in Bhutan. The impact of changing weather patterns on growing conditions has been underestimated, leading to disappointing harvests in the early years. Hazelnut trees are expected to bear fruit after the fifth year. In 2018, hazelnut growers in lower altitude orchards whose trees had reached maturity observed inconsistent and poor production. In 2021, MH undertook a comprehensive analysis (Sutton, 2021) to understand the root causes behind this issue.

The investigation included a climate variability assessment across the hazelnut growing regions of Bhutan, which found that Bhutan had not escaped the rapid climate change occurring across the Himalayas. Lower altitude orchards, below 2,400m, were subject to gradually rising temperatures, with farmers having to move their crops "up the hill" in order to maintain a climatic environment suitable for cultivation.

Hazelnut trees, like other fruit bearing trees, need the right amount of chill hours (the minimum number of hours of cold weather required to blossom) to bear fruit. Hazelnut trees are not self-pollinating, that is, they require male trees, also known as compatible pollenisers, to pollinate female tree blossoms.

Timing is crucial - the receptivity of the female blossoms needs to overlap with the timing of the pollen shed. With Bhutan experiencing a lower number of chill hours over the winter months, male trees are not producing pollen at the right time to pollinate female blossoms. This, in turn, has led to inconsistent and poor fruiting in hazelnut orchards.

Upon discovering a decline in the flowering of its chosen production variety due to climate change, MH launched the Orchard Conversion Programme (OCP) in 2022 to replace the affected variety at elevations below 2,400m.

Grafting New Hazelnut Varieties for Climate Resilience and Adaptation

The OCP aims to make hazelnut trees more resilient to climate change by grafting branches from varieties that need less cold (lower chill-hour) onto the roots of existing trees that require more cold (high chill-hour). Since weather conditions can vary significantly even within the target altitude range (1,700 to 2,400 metres above sea-level) due to factors like slope, direction and location, using a diverse mix of pollen varieties helps ensure better tree growth and higher nut production.

By the end of 2024, the programme had grafted 900 acres across 18 dzongkhags, engaging its field staff, local grafters and hazelnut growers. The introduction of climate resilient varieties plays a crucial role in bolstering farmers' resilience against the impacts of climate change. Early effects of the grafting of new varieties have already been seen in the doubling of the hazelnut harvest from five tonnes in 2023 to more than 10 tonnes in 2024.

To further enhance the climate resilience of its farming partners, Mountain Hazelnuts implements various strategies throughout the agricultural value chain. These include improved irrigation and water storage, integrated pest management, and enhanced post-harvest practices. By sharing best practices, the initiative ensures that smallholder farmers can adapt to changing climatic conditions and optimise their yields.

Conclusion

The Mountain Hazelnuts project in Bhutan presents a compelling model of integrating economic development with environmental sustainability, particularly in the face of climate change. As the project has demonstrated, the cultivation of hazelnuts offers economic opportunities for rural communities while also contributing to soil conservation and forest regeneration. However, the challenges posed by climate change, such as unpredictable weather patterns, temperature fluctuations, and increasing frequency of extreme events, remain an ongoing concern. In response, the

project's proactive approach in adopting climate-resilient farming practices and introduction of climate resilient hazelnut varieties is an important step forward.

Looking to the future, the success of hazelnut and, perhaps, other cash crop production in Bhutan will depend on continued adaptation to evolving climate conditions and the scaling of sustainable practices across the agricultural sector. Further research into climate-smart agricultural strategies, along with investments in local capacity-building and infrastructure will be crucial in ensuring the long-term viability of the project. The model set by Mountain Hazelnuts could offer valuable insights for similar initiatives in other vulnerable regions, demonstrating how climate resilience and economic growth can be mutually reinforcing.

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