



Research Article

Possible Obstacles And Risks Linked To Chilghoza Pine (*Pinus gerardiana*) Farming and Marketing in Pakistan

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Abstract | The chilghoza pine, scientifically known as *Pinus gerardiana* or pine nut, holds significant importance as a non-timber forest species in Pakistan. The Chilghoza nut, rich in unsaturated fatty acids, natural sugars, essential vitamins, and vital minerals, stands as a highly prized and nutritious food source. Unfortunately, it is classified as a threatened species by the International Union for Conservation of Nature (IUCN) due to inadequate management policies and overexploitation. The use of subpar processing technologies is a primary concern, leading to decreased acceptability in major markets and affecting the quality and nutritional value of pine nuts. To enhance the market value of pine nuts, it is imperative for Research institutions must collaborate and take immediate action. To achieve this goal, efforts should focus on developing high-quality pest-resistant seeds and proposing effective treatments to prolong duration that pine nut seeds remain viable processing and commercial storage. Additionally, the government should initiate new projects to better understand the life cycle dynamics of pine nuts and promote sustainable conservation measures. By doing so, we can work towards safeguarding the future of this valuable species and preserving its ecological significance in Pakistan.

Received | March 28, 2024; **Accepted** | July 28, 2025; **Published** | August 23, 2025

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Citation | Khan, S.U., N. Zarif, B. Ahmed, S. Ahmad and A. Ali. 2025. Possible obstacles and risks linked to chilghoza pine (*Pinus gerardiana*) farming and marketing in Pakistan. *Pakistan Journal of Forestry*, 75(2): 47-58.

DOI | <https://dx.doi.org/10.17582/journal.PJF/2025/75.2.47.58>

Keywords | Pine nut, Chilgoza, Marketing, Natural regeneration, Forest, Pakistan



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Introduction

Pinus gerardiana, also known as Chilghoza pine, is an indigenous tree discovered in the Northwestern Himalayas of eastern Afghanistan, India, and several dispersed regions within the Hindu-Kush Himalayas. Its preferred habitat lies at elevations ranging from 1800 to 3350 meters. Other trees such as Blue pine (*Pinus wallichiana*), Deodar (*Cedrus deodara*), Juniper (*Juniperus excelsa*), and Oak (*Quercus ilex*) are

commonly observed growing together (Richardson and Rundel, 1998). This remarkable species has earned the title of “champion of rocky mountains” due to its ability to thrive in challenging conditions typical of the inner Himalayan region. It inhabits dry temperate regions with low temperatures and receives scanty precipitation, mainly in the form of snow during the winter. *Pinus gerardiana* also has a crucial role in soil conservation by serving as a superb soil binder, effectively averting extensive soil erosion

in the otherwise unstable and delicate terrain of the region (Sehgal and Khosla, 1986).

The grazing and harvesting of edible seeds hinder the natural regeneration process (Shaikh, 1993). To collect green cones in September, they are piled up and sun-dried until they open and release the seeds. The cones are taken out from the trees using a long pole with an iron hook. Chilgoza is a slow-growing tree, as evidenced by a study where it took 64 years to reach a 2-meter girth at the stump level (Javed, 2009). Due to its economic importance to the locals, they refrain from cutting it down until it naturally dies, resulting in the presence of rugged and very old trees in the area. Some dry trees also stand in the jungle, as there is little demand for timber and extracting it is challenging. A moth extensively attacks the seeds while they are still in the cones on the tree. The Chilgoza pine primarily grows in the North-eastern part of the Zhob district. Sadly, the worldwide decline in Chilgoza pine growth has led conservationists to include it in the IUCN Red List of Threatened Species (2013). In the Gilgit Baltistan region, the Chilgoza forests have been heavily exploited without any proper management plan, lacking sustainable forest management based on scientific principles. Most current research primarily centers on the socio-economic and livelihood factors concerning forest communities, rather than tackling the crucial challenge of regeneration. Regrettably, there is insufficient data available to accurately assess the current condition and future outlook of these Chilgoza forests because no research has been conducted on this topic to date.

Significance and relevance for research and socio-economic purposes

Chilgoza pine is significant and relevant for research and socio-economic purposes due to its ecological importance, economic value, potential for biodiversity conservation, contribution to local livelihoods, and potential climate change resilience. Studying and preserving this species can have wide-ranging benefits for both the local communities and the global environment.

Socio economic importance

The Chilgoza pine (*Pinus gerardiana*) holds significant economic potential for improving the livelihoods of rural communities residing in mountainous regions, who heavily rely on forest resources (Khan, 2009).

This particular species is prevalent in the eastern and south-east forests of Afghanistan, serving not only as a provider of various environmental benefits but also as a crucial source of sustenance for neighbouring communities (Mail, 2012). The pine nuts harvested from Chilgoza pine are a major non-timber forest product in Afghanistan and are internationally traded. While being held in high regard within worldwide markets, individuals from the nearby village receive less than \$10 for each kilogram of pine nuts without shells (Kuhn *et al.*, 2006). Chilgoza plays a vital protagonist in driving socio-economic progress in the pastoral areas surrounding its forests (Mail, 2012). Within the *Pinus* genus, there are 18 edible species of pine nuts, including *Pinus gerardiana*, *Pinus koraiensis*, and *Pinus pinea*, all of which are essential for substantial production and trade (Kuhn *et al.*, 2006).

The Chilgoza pine (*Pinus gerardiana*) is the only type of pine tree with edible nuts in Afghanistan, India, and Pakistan, according to Kumar and Hamal (2009). Local communities are usually responsible for tasks like harvesting, processing, drying, and extracting the nuts (CAB International, 2002). The popularity of Chilgoza pine nuts extends beyond the region, with worldwide trade and usage, whether raw, roasted, or as an ingredient in various dishes (Sharma *et al.*, 2013).

Nutritionally, Chilgoza pine nuts are noteworthy for being a rich source of unsaturated fatty acids with no cholesterol (Distaillats *et al.*, 2010), while also containing significant amounts of starches, proteins, and minerals (Malik *et al.*, 2012). Specifically, every 100 grams of pine nuts provide 31 grams of protein (Kuhn *et al.*, 2006), along with 4.1% sugar, 52.1% oils, and 24.4% moisture in fresh seeds (Malik *et al.*, 2009). Beyond their culinary and nutritional value, the Chilgoza pine tree possesses several other valuable characteristics. The bark, wood, leaves, and cones of the tree contain resin and generate oleoresins. Tapping the bark of the tree allows for the extraction of these oleoresins, though the quantities obtained are not significant, as stated in WCS (2008). These oleoresins carry turpentine oil and other compounds that are utilized in different sectors like Cosmetics, waxes, herbal remedies, culinary oils, coatings, and tar (Mail, 2012; WCS, 2008). Furthermore, the timber from the Chilgoza pine stands out due to its resinous quality, strength, suppleness, uniform consistency, and effortless cutting

properties. The outer part of the wood appears as a white to yellowish-white color, while the inner core spans from reddish-brown to deep brown hues. The typical density of the wood is 580 kg/m³.

The timber obtained from the chilgoza pine holds minimal importance and isn't widely used (CAB International, 2002; Khan and Khan, 1992; Mail, 2012). It is utilized in various contexts such as planking, residential building, crafting doors, windows, rafters, ceilings, and other woodworking tasks (Anonymous). Local communities use chilgoza pine wood as fuel (CAB International, 2002; Mail, 2012). The existence of chilgoza pine forests significantly contributes to the socio-economic advancement of rural communities living in close proximity to these wooded areas (WWF-P, 2014). In India, this particular type of tree holds great importance because of its substantial role in supporting the local economy (Thakur *et al.*, 2014). The Chilgoza pine forests provide more than just valuable pine nuts; they also supply fuelwood, medicinal plants, grazing land, and protection for livestock, while also functioning as a wildlife habitat and offering various environmental benefits. The residents of the area highly value and gather chilgoza pine nuts for selling purposes (Eckenwalder, 2009). The vacant cones also function as fuelwood (Anonymous), particularly in regions lacking other tree species close to villages. Furthermore, the timber is at times utilized in household building projects (WCS, 2008). Regrettably, the chilgoza pine forests in Afghanistan have not been sufficiently researched, resulting in limited knowledge regarding the socio-economic significance of this species.

According to Richardson and Rundel (1998), The economic importance of Chilgoza nuts has resulted in widespread harvesting by local communities, leading to almost complete depletion of the cone population. Pakistan stands out as one of the primary producers of Chilgoza nuts, with approximately 13,000 locals in the Suleiman Mountain range relying on nut harvesting as a source of income each year. Consequently, natural regeneration is limited to remote and inaccessible areas, accounting for a mere 5% (Singh and Chaudhary, 1993). To address this issue and maximize its economic benefits, both governmental and non-governmental organizations are making efforts to cultivate and enhance the utilization of Chilgoza nuts.

Table 1: *The estimated production of Pine nuts in different countries (INC, 2016).*

S. No	Country	Production metric tons	Percentage
1	China	5000	26
2	Russia	4050	21
3	Korea	3000	15
4	Afghanistan	3000	15
5	Pakistan	3000	15
6	Others	1525	8
	Total	19600	100

Source: INC (2016).

The enhancement of human social, natural, political, physical, and financial conditions can lead to an improvement in people's livelihoods. This research investigates the potential of Chilgoza nuts to positively impact the economic situation of local residents in the mountainous region of Shishi Koh Valley, District Chital, Pakistan, as it serves as their primary source of income. Previously, Chilgoza nuts were solely used for domestic consumption until the Innovation for Poverty Reduction Project (IPRP), a non-government organization, recognized their economic significance in 2003. The study highlights that middleman exploited this natural resource before 2003, visiting the Shishi Koh Valley annually to purchase Chilgoza pine at an extremely low price (around 0.5 cents per 5 kg).

As a result, there was a surge in demand and prices for Chilgoza cones, branches, and trees, leading to unsustainable harvesting practices. To address this issue, the IPRP initiated an awareness and training campaign in the Shishikoh Valley, District Chital, Pakistan. The campaign aimed to educate the local communities about the economic and ecological significance of the Chilgoza pine. Furthermore, the Information and Public Relation Department (IPRD) worked on enhancing the harvesting, processing, and marketing techniques within the communities. This study focuses on the role of Chilgoza nuts in uplifting the economy and improving the livelihoods of the local communities, with particular emphasis on the pre- and post-IPRP interventions in 2003 (IUCN, 2007).

Production and export status of pine nuts in Pakistan

Chilgoza trees have played a significant role in constituting 20% of Pakistan's overall land coverage according to Urooj *et al.* (2020). The yearly yield of

chilgoza nuts is estimated at approximately 5600 tons, predominantly sourced from South Waziristan which accounts for 90% of the production. The region of South Waziristan allocates roughly 20% of its forested areas to cultivating pine nut trees, spanning from Shakai to Angoor Adda along the border with Afghanistan. The nuts collected are then sold in Bannu, D.I. Khan, Peshawar, Rawalpindi, and Lahore. After undergoing processing, these nuts are prepared for distribution in both local and international markets (Wazir and Javed, 2018). Pakistan exports approximately 3500 to 4000 metric tons of pine nuts annually, constituting roughly 15% of the worldwide pine nut production. A notable portion of these pine nuts is shipped to destinations such as the Middle East, China, the UK, USA, and Europe (Saeed, 2019).

The policies and responsibilities of both the public and private sectors in facilitating the marketing of pine nuts in Pakistan

Pine nuts fall into the category of internationally traded items due to their consumption in both raw and processed forms. In addition to being sold as whole nuts, Various value-added products like nut powder, nut butter, nut toffees, and caramel items are in high demand worldwide (Sharma et al., 2013). Pine nuts hold considerable economic importance in both domestic and global markets when compared to their timber counterparts. Nevertheless, the marketing of pine nuts is not as widespread in Pakistan, with only two sectors involved in this industry, World Wide Fund (WWF-Pakistan) and Federal institutions, are actively involved in promoting pine nut regeneration and marketing. Unfortunately, there is a lack of proper policies and legal enforcement to protect this endangered biological resource in Pakistan (Urooj, 2019). The normal regeneration rate of chilgoza stands at a mere 15%. Because of the strong demand and valuable market, each harvested chilgoza pine nut is purchased, resulting in only a small number of seeds available for natural regeneration, as those that drop to the ground are swiftly broken down by fungi or eaten by insects. Furthermore, it is worth noting that the distribution of pine nut areas is extremely limited, resulting in the sale of harvested seeds only in prominent markets within Pakistan or for export purposes (Xiang et al., 2019). The demand for pine nuts has been steadily rising in the US, but comprehensive global trade data for this nut is lacking, with even EUROSTAT and Codex Alimentarius failing to establish proper protocols for pine nut

trade in Pakistan (Awan and Pettenella, 2017). Previous research indicates that pine nut processing has doubled due to the heightened international demand, and as a result, there has been an increase in professional engagement of local communities in recent years (Latif and Shinwari, 2005).

The difficulties linked with chilgoza nuts in Pakistan

The earth's ecosystem relies significantly on natural forests, which also support the well-being of communities. In countries like Pakistan, especially in rural and northern regions, advanced food processing technologies are lacking among communities. This results in a strong dependence on forests for livelihood, as advanced agricultural methods are limited. These individuals were previously engaged in the act of clearing natural forests. As a result, the extensive felling of trees and manual gathering have led to a significant rise in the rate of deforestation. According to the findings from the International Union for Conservation of Nature (IUCN) report, the pine nut species has been classified as red-listed by the IUCN due to its status as a near-threatened and endangered species (Urooj, 2019). Numerous challenges are currently affecting the cultivation of pine nuts across various areas in Pakistan. Certain problems arise from natural factors like climate change, reduced rainfall, and frequent droughts leading to decreased vegetation and eventual deforestation. On the other hand, human-related issues, such as unauthorized tree felling, extensive use of land for animal grazing, and inadequate law enforcement, contribute to the sluggish development of these trees (Ali et al., 2014). The WWF has noted that the trees are utilized by the nearby communities for obtaining wood and fuel. However, these trees possess significant economic worth because of the nuts they produce. As a result, the discussion about the chilgoza pine has persisted over the years in Pakistan, primarily because of challenges linked to both preharvest and post-harvest aspects.

The difficulties related to the cultivation and collection of pine nuts in Pakistan

The Chilgoza pine, a type of pine tree native to Pakistan, is known for its gradual development, taking around 64 years to achieve a circumference of 2 meters at the base. During its early growth stage, it needs 3 to 4 years to reach a size suitable for planting. Pine nut trees in low temperate regions face challenges such as low temperatures and scarce

precipitation during their growth, as highlighted in studies by [Akbar et al. \(2014\)](#) and [Kumar et al. \(2016\)](#). Unfortunately, the natural regeneration of Chilgoza trees has been declining significantly over time. The decrease can be linked to unorganized tree removal and the gathering of pine cones by the local community for consumption and sale, as reported by [Kumar et al. \(2016\)](#). Moreover, the delayed process of sprouting and regrowth is impacted by elements such as reduced seed production during years when seeds are generated and the dormancy of seeds due to biological pressures. To address the reduction in seed germination time and promote Chilgoza tree growth for commercial purposes, some research projects have been conducted to control biotic factors in their natural habitat, but these efforts remain limited ([Kumar et al., 2014](#)).

The weight of pine seeds poses a hindrance to their wind dispersal, leading to a slow regeneration of the trees. Furthermore, the slow rate of chilgoza tree germination is also influenced by environmental factors like decreased humidity, elevated temperatures, and frost. Young seedlings of this species are particularly susceptible to damage and dehydration caused by environmental stress compared to older ones ([Shalizi et al., 2018](#)). Moreover, the development of young plants is notably impacted by the size of the seeds and the substrate in which they cultivate. Smaller seeds experience nutrient deficiency, resulting in a slower growth rate compared to larger seeds. Studies have demonstrated that large seeds and growing media containing vermicompost have a positive impact on seedling growth ([Parker et al., 2004](#)).

The extended human impacts over the past fifty years have significantly affected the development of *Pinus gerardiana*, a species located in the Sulaiman Mountain Range in Pakistan. This species thrives at altitudes between 2700 m and 3400 meter above sea level. The situation is particularly concerning in the lower zone of SMR, where this species has completely disappeared, posing a serious threat to the chilgoza's survival in the region. Contributing factors to the poor regeneration of this species include excessive tree cutting, uncontrolled animal grazing, unrestricted access by local communities, and unsustainable nut collection. Furthermore, the slow regeneration of *Pinus gerardiana* is directly impeded by various factors including soil erosion, sandy soil, drought, inadequate nutrients (especially nitrogen), sunlight, unfavorable

winds, and steep slopes, all of which contribute to the challenging soil and environmental conditions ([Aziz et al., 2017](#)).

The main worldwide obstacle encountered by this at-risk species mentioned in the Red Data Book involves the difficulty in its natural regrowth due to the decline in the viability of its seeds as time passes. Several factors contribute to the slow regeneration process, including infrequent seed years and early dormancy ([Malik and Shamet, 2009](#)). Additionally, the presence of overgrazing animals in the pine forest, particularly goats, poses a significant threat to the growth of new seedlings and tree leaves. Furthermore, the occurrence of forest fires, often caused by the carelessness of visitors, also contributes to the sluggish regeneration rate. For instance, in 1999, a study reported a forest fire outbreak in the chilgoza forests of Kunday Qaisa, resulting in deforestation ([Shalizi et al., 2018](#)). The significant challenge in reviving chilgoza pine forests lies in the reforestation process, mainly because of the extensive trimming and removal of branches that occur during harvesting ([Groninger, 2012](#)). In the Chaprote forest, which is a natural conifer forest covering approximately 3.5 sq km, only 10% of the tree stand comprises chilgoza trees. The forest area's patchy cover, spanning about 14.5 sq km, further complicates the growth process. The slow expansion of the area is worsened due to the prevailing utilization of chilgoza wood as fuel ([Mumtaz and Dani, 1991](#)). To conserve this endangered species and improve regeneration, comprehensive efforts are required to address these various threats and challenges.

Pests have a negative impact on the growth of trees within a specific area. A research conducted in the forested areas of Gilgit Sai and Garobad Balti Gali regions in Pakistan uncovered that woolly flying squirrels inhabit pine trees, such as blue pine (*Pinus wallichiana*) and chilgoza pine, relying on pine needles as their primary food source. Fecal samples of four squirrels were collected and analyzed, confirming their complete dependence on pine needles for sustenance. The presence of these squirrels has been observed to cause damage to pine trees at higher elevations ([Zahler and Khan, 2003](#)).

During their growth stages, chilgoza trees are susceptible to attacks from pathogens and seed borers. A previous study reported that Indian meal moth (*Plodia interpunctella*) is a common household pest

known for infesting stored food products, especially grains, nuts, dried fruits, and cereals infestation in chilgoza tree seeds resulted in reduced seed rates (Kumar, 2016). In the Himalayas, north India, studies have identified insects such as *Dioryctria abietivorella* (Grote), fir cone-worm, and *Euzophera cedrela* (cedar cone-moth) as responsible for hindering natural regeneration of pine trees. These bugs deposit their young within pine cones and devour the seeds as a source of protein to fulfill their nutritional needs. Furthermore, birds, specifically *Nucifraga caryocatactes* subsp. *multipunctata* and Eurasian nut-crackers, frequently eat seeds that have dropped to the ground. This activity also hinders the process of natural regrowth (Peltier and Dauffy, 2009). For successful germination of pine seeds in nurseries, proper drainage is crucial. However, limited research has been conducted to investigate the influence of seed size and growing medium on plant germination (Kumar *et al.*, 2016).

The difficulties linked to processing and storing pine nuts in Pakistan

After gathering nuts from the trees branches, the first stage of processing includes forming piles of chilgoza cones indoors. According to local nut gatherers, around 30% of the losses happen while arranging these piles. The next stage includes removing the nuts from the pinecones. This is accomplished by placing the pinecones on a wooden surface and employing a wooden tool to loosen the nuts. This particular step is very important, yet it presents a difficulty because the nuts located towards the bottom of the cone are frequently harmed. Regrettably, there isn't a dedicated instrument accessible for this objective, and the frequently employed spatula crafted from local wood leads to a fracture rate exceeding 10% for the nuts. Consequently, the overall nut recovery using this method is very low, only about 5% of the healthy seeds are gathered, while the emptied cones are exclusively utilized for fuel (Aziz *et al.*, 2018).

Chilgoza nuts, compared to other nuts, demonstrate the lowest antioxidant activity, making them more susceptible to lipid oxidation, particularly when their shells are removed. This oxidation process leads to the development of various aliphatic ketonic, aldehyde, and alcoholic compounds, resulting in an unpleasant off-flavor and painty smell in the nuts (Haq and Abid, 2013). To stabilize the worth and improve the flavor of pine nuts, roasting is a crucial processing

step. Processors commonly use gas and wood roasting methods. However, wood roasting can be expensive and poses difficulties in acquiring sufficient wood fuel, leading to uneven heating and discoloration of the nuts due to hot spots. Additionally, wood smoking necessitates constant manual labor for wood cutting and fire tending (Kuhn *et al.*, 2006). The preservation of sound pine nuts is a significant concern in pine nut-producing countries. Unfortunately, limited information exists in the literature about the best storage practices for pine nuts. A study found that storing seeds in earthen pots at 10°C can maintain their viability from November to May (the sowing period) without any loss of viability (Malik *et al.*, 2013).

Pine nuts face significant risks of developing off-flavors and unpleasant odors as a result of lipid oxidation, which leads to easy rancidity during extended storage (Hoon *et al.*, 2015). Storage houses often witness fungi and nut borers attacking unsold nuts, causing a decline in quality within weeks of harvest. To address this issue, a study suggests solar drying and packaging in aluminum laminate pouches to prolong the shelf life of pine nuts (Thakur *et al.*, 2012). This aligns with findings indicating that long-term storage of pine nuts results in off-flavor development, but temperature-controlled storage can effectively reduce oxidation rates. Additionally, applying low moisture treatment can preserve the sensory qualities of the seeds for up to 12 months (Cai *et al.*, 2013).

Pine nuts in Pakistan: Addressing regulatory and marketing challenges

In Pakistan, there exist minimal rules pertaining to the promotion of pine nuts, which function as a way to generate income for the nation. These pine nut trees predominantly grow in small clusters in the southern region of Chitral, at elevations ranging from 1800 to 3500 meters. The local community in Chitral has a strong affinity for these pine nuts as dried fruits, and for many years, they used to harvest the seeds, even when immature, for personal consumption or as gifts during traditional occasions. Recently, there has been a notable shift as people have become more aware, leading to an increase in the marketing of pine nuts to generate income (Ahmed, 2007). In the Doyan valley, located approximately 50 km away from Tehsil Jaglot in district Gilgit, a study was conducted. This valley is home to around 400 households, and the residents primarily engage in cattle rearing, relying on pasture

grazing for their livestock.

The valley experiences a rapid increase in the growth of pine nuts, but their full capacity is limited due to insufficient law enforcement and excessive grazing by cattle. The valley's population, mostly illiterate, lacks awareness about floral species, leading to the cutting of valuable trees, including endangered species. Marketing has been a long-standing challenge for the growth of chilgoza, a type of pine nut. An investigation carried out through surveys within the Kalash valley, situated in the southwestern region of the Chitral district in Pakistan, revealed that the region's major agricultural cultivation includes corn, wheat, beans, potatoes, vegetables, walnuts, chilgoza, and almonds. The economic requirements of the Kalash community predominantly rely on agricultural and forest resources. Chilgoza cultivation occurs in modest sections, with residents manually harvesting the seeds by ascending the trees, extracting seeds from the cones, and occasionally detaching the cones directly from the trees. The seeds are mostly consumed locally, with minimal marketing in cities, which hinders the natural regeneration of the trees in the area. According to the study, approximately 156 individuals are involved in seed collection, and they mainly sell the seeds in nearby regions for profit (Ahmed and Latif, 2007). The lack of sustainable practices and limited marketing opportunities pose significant challenges for the long-term growth of chilgoza in the region (Ali et al., 2014).

The promotion of pine nut sales encounters major obstacles, mainly because there are no nearby markets and they are far from major markets. As a result, most of the pine nuts that are collected are typically purchased by local traders and people in the nearby area. The proceeds resulting from sales are subsequently divided among the nearby communities and residents in accordance with their respective contributions (Shalizi and Khurram, 2016). Research conducted in the Kalash valley highlights that collectors often sell their pine nuts to local markets in Wana through a middleman, as they lack access to larger markets in the country. This arrangement leads to economic losses for the collectors, while the middleman reaps all the benefits. Moreover, there is a lack of awareness among people regarding marketing strategies and techniques to add value to the nuts. Unfortunately, the regulatory authorities have not made any efforts to upgrade the supply chain and marketing of chilgoza in Pakistan

(Sher et al., 2014).

In the global trade of chilgoza nuts, Pakistan faces numerous marketing and economic issues due to the presence of toxins and the occurrence of pine mouth syndrome (PMS). PMS typically manifests 24 hours after consuming an infected nut. This problem is primarily associated with the Chinese nut species, leading to a negative impact on the European market and resulting in the banning of Chinese nut imports (Ballin, 2012).

Present situation: The significance of management strategies and research initiatives in the preservation of chilgoza forests in Pakistan

Pine nut forests in the country have never been subject to formal forest management due to their status as privately-owned lands controlled by various tribes. In particular, the chilgoza forest area located in SMR, Balochistan, is under the jurisdiction of the Sheranis tribe. This tribe is subdivided into the Largha Sherani group in Khyber Pakhtunkhwa and the Bergha Sherani group in Balochistan, responsible for its management. Within the Bargha Sherani tribe, the Oba Khel and Hassan Khel possess the majority of the forested area, while the Chual Khel tribe is responsible for a smaller portion. According to discussions with locals, the management of this forest in Balochistan has full authority over all its resources and production (Urooj and Jabeen, 2015).

Pakistan had pledged to augment forest cover by approximately 6% as part of its commitment to the Millennium Development Goals. However, this goal faced obstacles due to various provisional and federal government constraints. In recent years, the government has undertaken several significant endeavors, mainly sustainable projects, to promote chilgoza afforestation. To address financial challenges, Pakistan is seeking support from the Green Climate Fund (GCF), Global Environment Facility (GEF), and initiatives focused on reducing emissions resulting from deforestation and forest degradation (REDD) (FAO, 2018).

In addition to a few initiatives undertaken by WWF-Pakistan to protect the chilgoza in Pakistan, in 1991, WWF-Pakistan implemented a two-pronged strategy to decrease deforestation in pine nut forests and restrict the hunting of Markhor. In 1998, the Federal Ministry for Economic Cooperation

and Development introduced a research project named “Integrated Conservation and Development Program for the Chilgoza Forest Ecosystem and the Community reliant on it in the Suleiman Range”. Furthermore, in the Suleiman Region, WWF-P executed a two-year project to preserve the chilgoza forest, which resulted in an increase of approximately 260 hectares of forest area, higher nut production, and improved agricultural practices to support the livelihoods of local communities (Urooj and Jabeen, 2015).

In Suleiman Ranges, Balochistan, a research-based study was conducted from 1999 to 2019, focusing on assessing the health of chilgoza trees and mapping the land cover in the area. This study employed advanced techniques such as SRS and GIS. A supervised machine learning algorithm was employed to categorize chilgoza trees and various types of land cover. This approach led to the recognition of seven primary categories: Dense chilgoza, scattered chilgoza, olive trees, plant life, water bodies, unproductive land, and mountainous areas. The study also calculated the area of cultivable land under each class and their rotation.

The results of this inquiry unveiled that back in 1999, about 174 square kilometers were entirely engulfed by dense chilgoza forests. However, by 2009, this expanse had shrunk to 84.9 square kilometers. However, in 2019, there was a significant resurgence, with the thick forest cover expanding to approximately 127 km². The thin pine nut cover occupied areas of 77.5 km², 247.7 km², and 139.9 km² in 1999, 2009, and 2019, respectively. Overexploitation and overgrazing were identified as the primary factors responsible for the decline in chilgoza cover during the period 1999-2009. On the other hand, the slow resurgence in land vegetation post-2009 can be linked to the participation of both governmental and non-governmental entities in the preservation initiatives of the pine nut forest (Urooj and Jabeen, 2015).

Conclusion

Chilgoza, a valuable Non-Timber Forest Product (NTFP), possesses significant nutritional and medicinal properties, making it a highly sought-after nut species in both countrywide and global markets. Moreover, its trade provides essential income for the local communities residing in the forests. In order to

understand the challenges involved in harvesting and trading pine nuts in Pakistan, this review gathered information from literature sources. The emphasis was placed on management techniques, processing, storage, and regulatory concerns that influence the commercialization of *Pinus gerardiana*. The results showed that the local community has insufficient awareness regarding quality and safety standards, along with lacking marketing connections. A lack of financial resources hinders the establishment of adequate storage facilities for the pine nuts and acquiring advanced equipment for harvesting, gathering, and processing. The primary value-added practice, roasting, also faces limitations due to high initial investment costs. The roasting process brings out rich, nutty, and caramelized flavors through the Maillard reaction and caramelization, making the product more desirable to consumers.

The profit from selling this product is not evenly distributed among all members of the supply chain. As a result, most pine nut collectors tend to share the pine nuts primarily with their relatives and friends. Alongside human-related issues, natural factors like temperature, slow natural regeneration, weather disasters, insect pest attacks, and overgrazing of trees by animals contribute to the poor growth of chilgoza trees in Pakistan. Weak enforcement of regulations and inadequate national laws have endangered this valuable species, pushing it towards extinction. The lack of research focused on conserving chilgoza nuts is a significant issue, with no efforts being made to develop improved or resistant varieties for better cultivation. While there are limited studies on extending the shelf life of chilgoza nuts, their practical application remains limited to farm-level settings.

In general, the analysis indicates that the cultivation and promotion of pine nuts in Pakistan display considerable diversity, reflecting a variety of management practices. To enhance economic prosperity and protect the pine nut industry in the country, it is crucial for the management and regulatory bodies to implement specific measures and initiatives.

Novelty Statement

Despite the high economic and ecological value of Chilgoza pine (*Pinus gerardiana*), limited research has addressed the specific challenges faced in its cul-

tivation and commercialization in Pakistan's unique mountainous ecosystems. This study provides a novel insight into the multifaceted obstacles and risks hindering sustainable farming and market development of Chilghoza, aiming to inform targeted interventions for forest conservation and rural livelihoods.

Author's Contribution

Saif Ullah Khan: Main frame, data collection, final review.

Dr. Nowsherwan Zarif: Topic selection.

Salman Ahmad: Data analysis.

Basheer Ahmad: Proof reading.

Dr. Anwar Ali: Final review of the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

References

- Ahmed, A., 2007. Indigenous use of non-timber forest products in Kalash Valley Chitral, Pakistan FAO online paper. NWFP Forest Department, Peshawar, Pakistan.
- Ahmed, A. and A. Latif. 2007. Non-timber forest products: a substitute for livelihood of the marginal community in Kalash Valley, Northern Pakistan. *Ethnobot. Leaflet*, 11: 97-105.
- Akbar, M., H. Khan, A. Hussain, S. Hyder, F. Begum, M. Khan, A. Ali, S.A. Hussain, G. Khan and Q. Abbas. 2014. Present status and future trend of chilghoza forest in Goharabad, district Diamer, Gilgit-Baltistan, Pakistan *J. Biodivers. Environ. Sci.*, 5(5): 253-261.
- Ali, R., B.K. Ali, M.Z. Khan, G. Khan, S. Abbas and E.H. Ali. 2014. Baseline study of vegetation in Doyan valley district Astore, Gilgit-Baltistan, Pakistan *Int. J. Emerg. Trends Sci. Technol.*, 1(4): 452-462. [https://doi.org/10.15341/mese\(2333-2581\)/05.01.2015/007](https://doi.org/10.15341/mese(2333-2581)/05.01.2015/007)
- Awan, H.U.M. and D. Pettenella. 2017. Pine nuts: A review of recent sanitary conditions and market development. *Forests*, 8(10): 367. <https://doi.org/10.3390/f8100367>
- Aziz, M., A.M. Adnan, A.H. Khan, K.A. Abdella, A. Alqarawi, E.F. Abd-Allah, M.N.O. Alzain and T. Mahmood. 2018. Innovative approach for the management of medicinal plants: A case study of plant pine nuts (*Pinus gerardiana* Wall.). *Pak. J. Bot.*, 50(4): 1637-1644.
- Aziz, M., A.M. Adnan, S.K. Hussain, A. Hashem, A.A. Alqarawi and E.F. Abd-Allah. 2017. Comparative regeneration status of *Pinus gerardiana* in two forest-use types of Sulaiman mountain range near Pak-Afghan border region: Historical, current, and future perspectives. *Pak. J. Bot.*, 49(1): 227-236.
- Ballin, N.Z., 2012. Investigating cases of taste disturbance caused by pine nuts in Denmark. In: *Case studies in food safety and authenticity*. Woodhead Publishing. pp. 318. <https://doi.org/10.1533/9780857096937.6.318>
- CAB International. (2002). *Non-wood forest products for rural income and sustainable forestry*.
- Cai, L., C. Liu and T. Ying. 2013. Changes in quality of low-moisture conditioned pine nut (*Pinus gerardiana*) under near freezing temperature storage. *CyTA. J. Food*, 11(3): 216-222. <https://doi.org/10.1080/19476337.2012.727032>
- Destailats, F., C. Cruz-Hernandez, F. Giuffrida and F. Dionisi. 2010. Identification of the botanical origin of pine nuts found in food products by gas-liquid chromatography analysis of fatty acid profile. *J. Agric. Food Chem.*, 58(4): 2082-2087. <https://doi.org/10.1021/jf9041722>
- Eckenwalder, J.E., 2009. *Conifers of the world: The complete reference*. Portland, Oregon: Timber Press.
- FAO, 2018. *Reversing deforestation in chilgoza pine forests by assisting the local community*. FAO Pakistan Online Report. Published on October, 10, 2019.
- Groninger, J.W., 2012. Reforestation strategies amid social instability: Lessons from Afghanistan. *Environ. Manage.*, 49(4): 833-845. <https://doi.org/10.1007/s00267-012-9817-6>
- Haq, M.A. and H. Abid. 2013. Studies on shelf life extension of chilgoza (*Pinus gerardiana*). *Asian. J. Chem.*, 25(1): 343-348. <https://doi.org/10.14233/ajchem.2013.13033>
- Harrison, S.G., 1951. Edible pine kernels. *Kew Bullet.*, 6(3): 371-375. <https://doi.org/10.2307/4118007>
- Hoon, L.Y., C. Choo, M.I. Watawana, N. Jayawardena and V.Y. Waisundara. 2015. Evaluation of the total antioxidant capacity and antioxidant compounds of different solvent extracts of chilgoza pine nuts (*Pinus gerardiana*). *J. Funct. Foods*, 18: 1014-1021. <https://doi.org/10.1016/j.jff.2015.05.007>

- org/10.1016/j.jff.2014.07.009
- INC, 2016. International nut and dried fruit council foundation. Nuts and dried fruits. Global statistical review 2015/2016. Available at <https://www.nutfruit.org/files/tech/Global-Statistical-Review-2015-2016.pdf> [accessed August 22, 2019]
- International Union for Conservation of Nature. (2013). The IUCN Red List of Threatened Species (Version 2012.2).
- International, C.A.B., 2002. Pines of silvicultural importance. Oxon, UK: CABI Pub.
- IUCN, 2007. International Union for Conservation of Nature and Natural Resources. Natural Resource Management for Improved Livelihoods in Northern Pakistan. Available at https://www.iucn.org/downloads/nrm_liv_2.pdf [accessed January 9, 2020]
- Javed, N., 2009. Thesis title current status of *Pinus gerardiana* in District Zhob Baluchistan.
- Khan, A.M., 2009. Economic benefits of hazelnut tree. Daily Newspaper Dawn. Available at <https://www.dawn.com/news/968000> [accessed January 15, 2020]
- Khan, S.M., and Khan, M.A. (2002). Status and conservation of chilgoza pine (*Pinus gerardiana*) in Pakistan. Pakistan Journal of Forestry, 52(2), 85–92.
- Kuhn, G., E. Hayashi and J.D.Z. Lea. 2006. Eastern region dried fruits and nuts subsector/market assessment. Roots of Peace for Development Alternatives, Inc. USAID Report.
- Kuhn, G., E. Hayashi and J.D.Z. Lea. 2006. Eastern region dried fruits and nuts subsector/ market assessment. Roots of Peace for Development Alternatives, Inc.
- Kumar, P., 2016. Studies on seed borer, *Plodia interpunctella* Hubner (Lepidoptera: Pyralidae) infesting seeds of chilgoza pine (*Pinus gerardiana* Wall.). Ind. For., 142(4): 394–399.
- Kumar, R., G. Shamet, H. Mehta, N. Alam, J. Tomar, O. Chaturvedi and N. Khajuria. 2014. Influence of gibberellic acid and temperature on seed germination in chilgoza pine (*Pinus gerardiana* Wall.). Ind. J. Plant Physiol., 19(4): 363–367. <https://doi.org/10.1007/s40502-014-0119-2>
- Kumar, R., G. Shamet, N. Alam and C. Jana. 2016. Influence of growing medium and seed size on germination and seedling growth of *Pinus gerardiana* Wall. Compost. Sci. Utiliz., 24(2): 98–104. <https://doi.org/10.1080/1065657X.2015.1048906>
- Kumar, S. and I.A. Hamal. 2009. Wild edibles of Kishtwar high altitude national park in northwest Himalaya, Jammu and Kashmir, India. Ethnobot. Leaf., 2009(1): 23.
- Latif, A. and Z.K. Shinwari. 2005. Sustainable market development for nontimber forest products in Pakistan Ethnobot. Leaf., 2005(1): 3.
- Mail, 2012. Chilgoza pine forest conservation and restoration plan draft report.
- Malik, A.R. and G. Shamet. 2009. Storage of *Pinus gerardiana* seeds: Biochemical changes and its applicability as vigor test. Res. J. Seed. Sci., 2(3): 48–55. <https://doi.org/10.3923/rjss.2009.48.55>
- Malik, A.R., G.S. Shamet, J.S. Butola, G.M. Bhat, A.A. Mir and G. Nabi. 2013. Standardization of seed storage conditions in chilgoza pine (*Pinus gerardiana* Wall.): An endangered pine of Hind Kush Himalaya. Trees, 27(5): 1497–1501. <https://doi.org/10.1007/s00468-013-0868-y>
- Malik, A.R., G.S. Shamet and M. Ali. 2009. Germination and seedling growth of *Pinus gerardiana* in nursery: Effect of stratification period and temperature. Indian J. For., 32(2): 221–225. <https://doi.org/10.54207/bsmps1000-2009-S514IG>
- Malik, A.R., G.S. Shamet and J.S. Butola. 2012. Natural regeneration status of chilgoza pine (*Pinus gerardiana* Wall.) in Himachal Pradesh, India: An endangered pine of high edible value. Appl. Ecol. Environ. Res., 10(3): 365–373. https://doi.org/10.15666/aecer/1003_365373
- Malik, A.R., G.S. Shamet, J.S. Butola, G.M. Bhat, A.A. Mir and G. Nabi. 2013. Standardization of seed storage conditions in chilgoza pine (*Pinus gerardiana* Wall.): An endangered pine of Hind Kush Himalaya. Trees, 27(5): 1497–1501. <https://doi.org/10.1007/s00468-013-0868-y>
- Mumtaz, S. and A. Dani. 1991. Management arrangements of the chaprote forest and their implications for sustainable development (with comments). Pakistan Dev. Rev., 30(4): 1075–1086. <https://doi.org/10.30541/v30i4Ipp.1075-1086>
- Parker, W.C., T.L. Noland and A.E. Morneault. 2004. Effect of seed mass on early seedling growth of five eastern white pine (*Pinus strobus* L.) families under contrasting light environments. Can. J. Bot., 82(11): 1645–1655. <https://doi.org/10.1139/b04-129>

- Peltier, R. and V. Dauffy. 2009. The chilgoza of Kinnaur. Influence of the *Pinus gerardiana* edible seed market chain organization on forest regeneration in the Indian Himalayas. *Fruits*, 64(2): 99-110. <https://doi.org/10.1051/fruits/2009005>
- Richardson, D.M. and P.W. Rundel. 1998. Ecology and biogeography of Pinus: An introduction. In: (eds. D.M. Richardson). 1998. Ecology and Biogeography of Pinus. pp. 3- 46. Cambridge University Press. ISBN 0-521-55176-5.
- Saeed, A., 2019. Chilgoza prices in Pakistan go nuts as exports soar. Arab News Pakistan Online Report. Published on November, 17, 2019.
- Sehgal, R.N. and P.K. Khosla. 1986. Chilgoza pine the threatened social forestry tree of dry temperate Himalaya. National Symposium on Research in Social Forestry for Rural Development, January 1-2.
- Shalizi, M.N. and S. Khurram. 2016. Socio-economic importance of chilgoza pine forest of Afghanistan: A survey-based assessment. *Asian J. Sci. Technol.*, 7: 3556-3559.
- Shalizi, M.N., S. Khurram, J.W. Groninger, C.M. Ruffner and O.T. Burney. 2018. Indigenous knowledge and stand characteristics of a threatened tree species in a highly insecure area: Chilgoza pine in Afghanistan. *For. Ecol. Manage.*, 413: 1-8. <https://doi.org/10.1016/j.foreco.2018.01.053>
- Shalizi, M.N., S. Khurram, J.W. Groninger, C.M. Ruffner and O.T. Burney. 2018. Indigenous knowledge and stand characteristics of a threatened tree species in a highly insecure area: Chilgoza pine in Afghanistan. *For. Ecol. Manage.*, 413: 1-8. <https://doi.org/10.1016/j.foreco.2018.01.053>
- Sharma, S., D. Gupta and Y.P. Sharma. 2013. Aflatoxin contamination in chilgoza pine nuts (*Pinus gerardiana* Wall) commercially available in retail markets of Jammu, India. *Int. J. Pharma. Biol. Sci.*, 4(2): 751-759.
- Sharma, S., D. Gupta and Y.P. Sharma. 2013. Aflatoxin contamination in chilgoza pine nuts (*Pinus gerardiana* Wall.) commercially available in retail markets of Jammu, India. *Int. J. Pharma. Biol. Sci.*, 4(2): 751-759.
- Sheikh, M.I., 1993. Trees of Pakistan. Pakistan Forest Institute Peshawar.
- Sher, H., A. Aldosari, A. Ali and H.J. Boer. 2014. Economic benefits of high-value medicinal plants to Pakistani communities: An analysis of current practice and potential. *J. Ethnobiol. Ethnomed.*, 10(1): 1-16. <https://doi.org/10.1186/1746-4269-10-71>
- Singh, N.B. and V.K. Chaudhary. 1993. Variability, heritability and genetic gain in cone and nut characters in Chilgoza pine (*Pinus gerardiana* Wall.). *Silvae Genet.*, 42: 61-63.
- Thakur, N.S., S. Sharma, V.K. Joshi, K.S. Thakur and N. Jindal. 2012. Studies on drying, packaging and storage of solar tunnel dried chilgoza nuts. *Arch. Appl. Sci. Res.*, 4(3): 1311-1319.
- Thakur, N.S., S. Sharma, R. Gupta and A. Gupta. 2014. Studies on drying and storage of chilgoza (*Pinus gerardiana*) nuts. *J. Food Sci. Technol.*, 51(9): 2092- 2098. <https://doi.org/10.1007/s13197-012-0692-1>
- Urooj, R., 2019. Status, distribution and dynamics of chilgoza pine (*Pinus gerardiana* Wall) forest in Suleiman mountain range, Pakistan. *Middle. East. J. Bus.*, 55(6589): 1-3.
- Urooj, R. and A. Jabeen. 2015. Present status of *Pinus gerardiana* Wall. in Pakistan: A review. *Middle. East. J. Bus.*, 55(2473): 1-3. <https://doi.org/10.5742/MEJB.2019.93606>
- Urooj, R., S.H. Sherani, L. Ehtasham, K. Younas and U. Izel. 2020. Geospatial analysis of chilgoza forest in Sulaiman mountainous range. *SN Appl. Sci.*, 2(11): 1-9. <https://doi.org/10.1007/s42452-020-03737-4>
- Wazir, I.M. and A.Y. Javed. 2018. Value chain study- pine nuts in South Waziristan. Khyber Pakhtunkhwa. Pakistan Report by Small and Medium Enterprises Development Authority (SMEDA). Ministry of Industry and Production, Government of Pakistan, pp. 1-27.
- WCS, 2008. Eastern forest program: Timber trade survey. Kabul, Afghanistan: Wildlife Conservation Society.
- WWF-Pakistan, 2013. Conservation of Chilgoza and associated scrub forest in selected villages of Tehsil Sherani District Zhob. Accessed via. https://wwfasia.awsassets.panda.org/downloads/annual_report_06.pdf. World Wild Fund. Pakistan.
- WWF-Pakistan, 2014. Conservation of Chilgoza forest ecosystem through natural resource-based livelihood improvement in Suleiman range. Pakistan: World Wildlife Federation.
- Xiang, X., Z. Zhang and G. Wu. 2019. Effects of seed storage conditions on seed water uptake,

germination and vigour in *Pinus dabeshanensis*, an endangered pine endemic to China. Seed Sci. Technol., 47(2): 229-235. <https://doi.org/10.15258/sst.2019.47.2.09>

Zahler, P. and M. Khan. 2003. Evidence for dietary specialization on pine needles by the woolly flying squirrel (*Eupetaurus cinereus*). J. Mammal., 84(2): 480-486. [https://doi.org/10.1644/1545-1542\(2003\)084<0480:EFDSOP>2.0.CO;2](https://doi.org/10.1644/1545-1542(2003)084<0480:EFDSOP>2.0.CO;2)