

Pine nut value chain analysis in Mongolia

Value chain analyses assist in informing policy dialogue and investment operations. They help the understanding of how agricultural, aquaculture and fisheries development fits within market dynamics. They permit an assessment of the value chains' impact on smallholders, businesses, society, and environment.

The European Commission has developed a standardised methodological framework for analysis (https://capacity4dev.europa.eu/projects/value-chain-analysis-for-development-vca4d/info_en). It aims to understand to what extent the value chain allows for inclusive economic growth and whether it is both socially and environmentally sustainable.

The value chain context

The Mongolian pine nut value chain is a strategic non-mineral export, contributing 0.6% to national GDP and 7.8% to agricultural and forestry GDP. The sector relies entirely on wild harvesting from 612,000 hectares of state-owned, natural Siberian pine forests, with no plantations. Production is driven by an estimated 60,000 to 70,000 harvesters, primarily seasonal herders and rural residents operating informally. The value chain is structurally simple: harvesters supply 70–80 wholesalers, who consolidate and transport nuts to around 10 processing companies mainly in Ulaanbaatar. Key constraints include severe climate vulnerabilities - particularly forest fires affecting 28% of forests in the country and seasonal temperature increase probably disrupting cone production cycles, competition for a limited resource, issues with forest monitoring and law enforcement, logistical challenges operating in remote forest areas, and a highly concentrated market structure heavily dependent on bulk exports to China.



The European Union intervention

The European Union funded this VCA4D report (VCA4D CTR 2017/392-416) to support policy dialogue between the EU Delegation and the Government of Mongolia. Regarding policy alignment and sustainability initiatives, the intervention provides essential data to assist the implementation of the EU's flagship STREAM+ programme, whose forest component is managed by GIZ. In terms of financial support, the study is intended to guide future sustainable investment decisions by the European Investment Bank and the European Bank for Reconstruction and Development.

The EU–Mongolia Forest Partnership was formalized with a Memorandum of Understanding signed at COP27 in November 2022, with a roadmap adopted in July 2023, and aims to protect, restore, and sustainably manage Mongolia's forests while strengthening forest-based value chains and governance. Two active projects underpin the partnership: STREAM+, which supports the legal framework, forest value chains, and vocational training schools, and the FGVC project, which builds the capacity of forest administration at both central and decentralized levels. The European Investment Bank is also preparing a sovereign loan of €100 million, blended with European Commission and other international financing, to expand Mongolia's forest cover, boost revenues for local communities and the national budget, and reduce the country's reliance on imported wood products.



Functional analysis

Production

Average production for 2025 is estimated at 16,350 tons of unshelled pine nuts, significantly exceeding the officially approved quota of 9,512 tons. Yield variability is extreme due to natural 3-5 year masting cycles, with harvests fluctuating from near-zero to peak yields of 61,000 tons. The agricultural structure involves approximately 65,900 self-employed seasonal harvesters working informally together in forest camps. Production exhibits strong regional differences, concentrated in the Khentii Mountains (77% of Siberian pine area, estimated harvested volume in 2025 9,150 tons), Khövsgöl Mountains (17%, 5,501 tons), and Khangai Mountains (6%, 1,699 tons). The sector faces severe climate constraints, as Mongolia has experienced a 2.5°C temperature rise over 80 years, increasing the risk of forest fires, and causing permafrost thaw. Unlike in other pine nut-producing countries, harvesting relies on striking trees with heavy wooden hammers, a practice that causes systematic bark scarring and potentially weakens long-term forest health.

Processing, Marketing and Trade

The processing sector is centralized in Ulaanbaatar, comprising 10 processing companies registered as Professional Forest Enterprises. They perform shelling, sorting, drying, and packaging, achieving kernel yields of 35–40%. Over 90% of processed kernels are exported. Trade flows are overwhelmingly directed to China, which absorbs 90% of volume and 85% of export value, purchasing bulk kernels in 25–50 kg bags. High-end processors export smaller, premium lots to the EU, USA, Japan, and South Korea. Logistics rely on rented trucks transporting unshelled nuts 300–800 km from rural wholesale yards to Ulaanbaatar, costing 300–500 MNT/kg. Regarding price competitiveness, Mongolia records the lowest average export unit value globally (USD 12.6/kg kernels) due to its bulk market positioning.

Sub-chains

Regional geographic variations do not form distinct economic sub-chains. Instead, the sector is segmented into two processing sub-chains: bulk export and high-end processing. Both rely on wholesalers who source from registered or unregistered harvesters. The bulk export sub-chain involves seven seasonal processors handling approximately 75% of total shelled volumes (4,570 tons).

Governance

Institutional governance involves the Ministry of Environment and Climate Change (MECC), the National Forest Agency (NFA), and Inter-Soum Forest Units (ISFUs). The government has established a system of quotas since 2022, that registered Professional Forest Enterprises can bid for through a digital auction system. This system taxes and sanctions commercial harvesting, but is in contradiction to the Law on Natural Plants (1995), the Forest Law (2012), and the Law on Special Protected Areas (1994) which variously prohibit it or severely limit it, especially in protected areas - where it is nonetheless widely practiced. Regulatory oversight is extremely weak due to severe understaffing and the remoteness of forest sites, allowing informal over-harvesting to persist. Forest User Groups are legally recognized but practically excluded from value chain participation or governance. The annual quotas generate substantial nature-use fees and auction proceeds (7.3 billion MNT in 2025) for local soum governments.

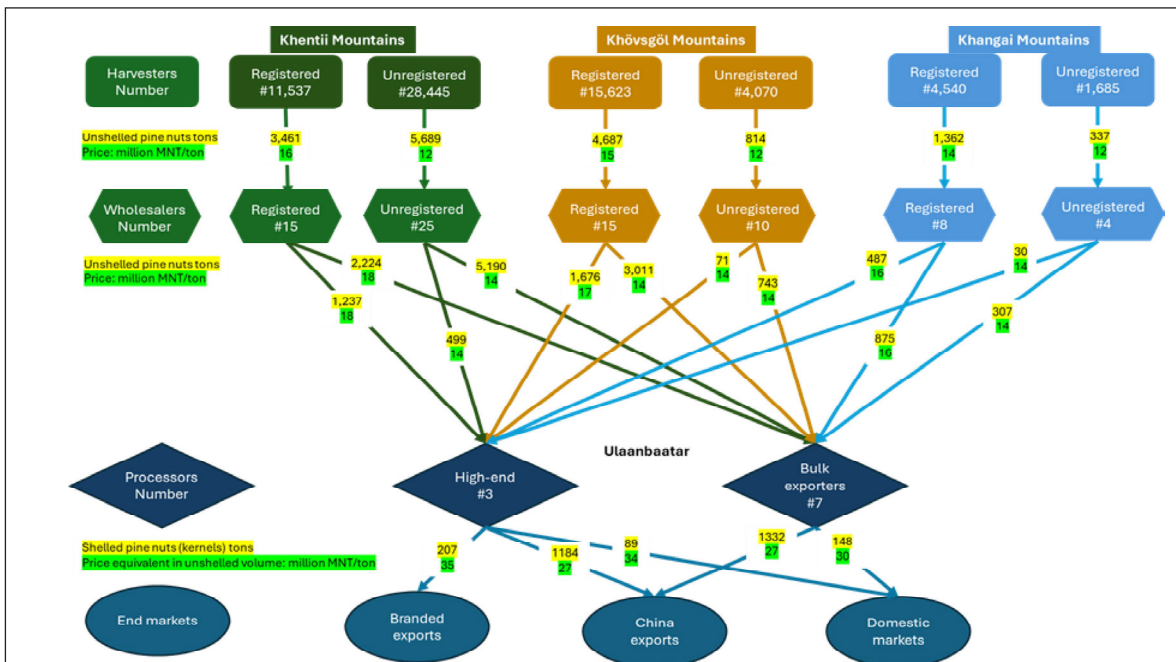


Figure 1: Flow chart of the VC

What is the contribution of the value chain to economic growth?

Financial viability for the actors

The value chain is highly profitable but characterised by significant asymmetries across actors. Harvesters earn high but seasonal returns, yielding net operating profits (NOP) of 257,000–297,000 MNT/day in formal channels and around 220,000 MNT/day informally, with margins of 70–90%. However, these incomes are short-term and depend on highly variable harvest conditions. Transport is their primary cost pressure. Wholesalers secure NOP margins of 9–12% (in formal channels) or up to 26% (informally), but remain constrained by high raw material purchase costs (over 90% of total costs) and transport. Processors generate the highest absolute profits, with high-end processors capturing a 23% margin (29.3 billion MNT) and bulk exporters achieving 30% (105.9 billion MNT) due to cheaper informal sourcing and economies of scale. The State, acting as the landowner, also captures value, generating 7.3 billion MNT annually for soum governments through auction proceeds and nature-use fees.

Impacts on the national economy

The value chain generates 460.4 billion MNT in total direct and indirect value added, representing 0.6% of national GDP and 7.8% of agricultural and forestry GDP. As a major non-mineral export, contributing 0.1% to national exports and generating a positive trade balance of 67.7 billion MNT. Fiscal contributions are highly positive, generating 65.6 billion MNT in net taxes (0.2% of the state budget) with zero public subsidies. Domestic economic integration is extraordinarily strong; 95.3% of the value chain output is retained within Mongolia, as operations rely on domestic labour and domestic transport rather than imported inputs.

Comparison of sub-chains

Processors in the export sub-chain capture a high net operating profit margin of around 30% due to economies of scale and low input costs. The high-end processing sub-chain consists of three processors managing about 25% of the shelled volume (1,480 tons). This segment employs year-round permanent staff and utilizes advanced mechanized processing to supply branded and certified retail kernels to premium niche markets. While their profit margin is lower (around 23%) due to higher fixed costs, they drive structural value upgrading. Overall, Ulaanbaatar-based processors capture 47% of total direct value added, harvesters capture approximately 48%, and wholesalers capture just 6%.

Indicators	
VA Total / GDP	0.6%
VA Total / Agricultural and Forestry GDP	7.8%
VA Total / VC output (integration)	95.3%
VC Trade Balance/ National Imports	0.2%
VC Total Wages/National Wages	0.1%

Table 1: Key macroeconomic indicators

Viability in the international economy

Mongolia possesses exceptional structural competitiveness under free-trade conditions, evidenced by a Domestic Resource Cost (DRC) ratio of 0.04, meaning domestic factors represent a tiny fraction of foreign exchange generated. There are no macroeconomic distortions; both Nominal and Effective Protection Coefficients are 1.00. Despite this, Mongolia suffers severe structural disadvantages in value capture. It records the lowest average export unit value globally (12.6 USD/kg kernels), heavily trailing premium markets (25–40 USD/kg). This is driven by monopsony dependence on bulk export channels to China, limited downstream value addition in terms of packaging, branding, and market positioning, and an absence of certification or origin-based branding.

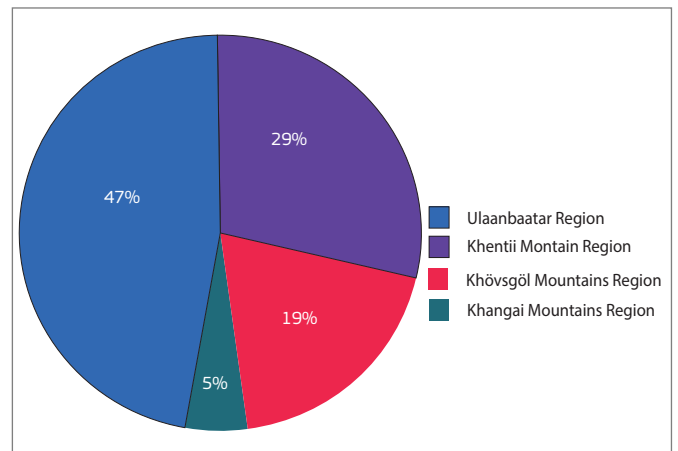


Figure 2: Value added shared across regions

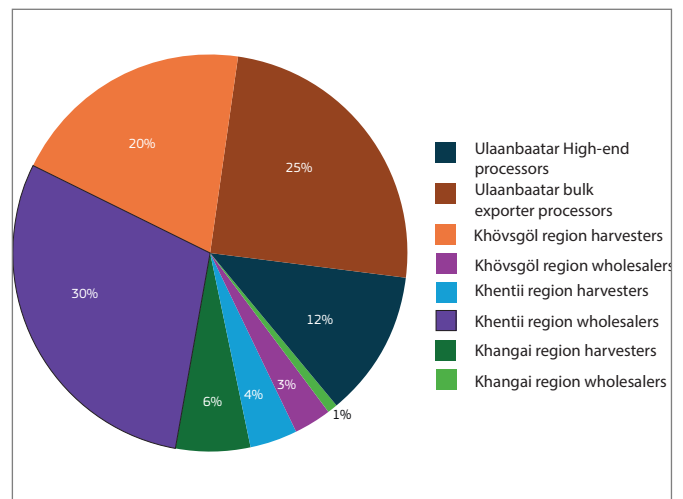


Figure 3: Net operating profit across regions

The value chain is highly profitable, structurally competitive, and heavily integrated into the domestic economy. It contributes significantly to agricultural GDP and public finances without requiring subsidies. However, structural dependence on bulk exports severely limits international value capture despite strong comparative advantages.

Is this economic growth inclusive?

Distribution of income among the actors

Income distribution is highly unequal, evidenced by a Gini coefficient of 0.6. Out of a total direct value added of 449.9 billion MNT, downstream Ulaanbaatar-based processors capture 47%, harvesters capture 48%, and wholesalers retain just 6%. Wages amount to only 14.1 billion MNT, as the vast majority of participants (harvesters) receive income strictly as net operating profit rather than formal salaries. Regionally, value creation is concentrated in Ulaanbaatar (47%) and the forest-rich Khentii (29%) and Khövsgöl (19%) regions, largely bypassing the Khangai Mountains (5%) (Figure 2). Inequalities reflect structural market concentration rather than poor upstream revenue, as harvesters lack bargaining power but still achieve high individual seasonal earnings.

In terms of pure net operating profit (362.4 billion MNT), processors capture 37% of the total (25% bulk exporters, 12% high-end), despite representing only 10 companies (Figure 3). Harvesters capture 55% of the total profit, but this is fragmented across an estimated 60,000–70,000 individuals.

Job creation and employment

The sector generates over 70,000 jobs, representing vital employment for rural communities. Harvesters account for the

overwhelming majority, representing around 95% of total employment, followed by 2,000 wholesalers and roughly 560 processors. For rural labour, the value chain acts as a highly lucrative livelihood supplement, paying harvesters 204,000–286,000 MNT per day, which is considerably higher than minimum or average wages for rural casual labour. Importantly, income from pine nut harvesting is counter-seasonal with major rural income streams from cashmere (in spring) and livestock sales (in late autumn).

However, the sector suffers from severe structural precarity. Fully 99% of all jobs generated are temporary, lasting only 10 to 90 days during the autumn harvest. Only high-end processors offer permanent, year-round employment, comprising just 1% of the workforce but contributing 11% of total annual labour days. Consequently, while the value chain generates massive short-term rural wealth, it fails to provide stable, long-term social protection.

Economic growth is broad-based but highly unequal. The sector delivers exceptional, high-paying seasonal employment to 60,000–70,000 rural harvesters, fundamentally supporting herder livelihoods. However, 99% of jobs are temporary, and a small oligopoly of Ulaanbaatar processors structurally captures 37% of all net profits.

Is the value chain socially sustainable?

Figure 4 and the following table provide an image of the main social consequences of the VC activities in six strategic domains.

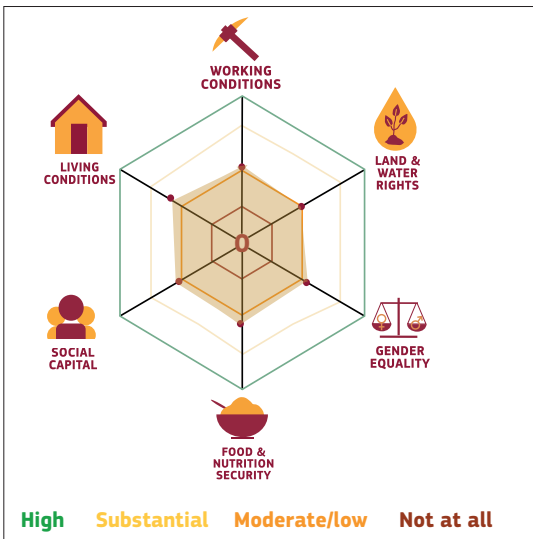


Figure 4 Social profile

The value chain is socially beneficial, providing crucial seasonal income that improves rural living conditions, food security, and debt relief. However, sustainability is constrained by the exclusion of Forest User Groups from governance, weak land tenure enforcement, and gender disparities in decision-making.

Working Conditions	<ul style="list-style-type: none"> Respect for labour rights is substantial. Harvesting involves heavy labour but is highly attractive due to exceptional daily earnings. Minor risks include unguarded machinery in wholesaling and potential child labour.
Land and Water Rights	<ul style="list-style-type: none"> De facto open access allows harvesters to operate without territorial disputes. However, weak tenure enforcement contradicts laws, enabling illegal commercial harvesting in Strictly Protected Areas and undermining environmental sustainability.
Gender Equality	<ul style="list-style-type: none"> Women comprise 25–30% of harvesters and 50% of processing staff. Economic participation is high, but the value chain is subject to more general norms that leave female influence in decision-making and public participation disproportionately low.
Food and Nutrition Security	<ul style="list-style-type: none"> Harvesting households appear to enjoy better diets than their non-harvesting neighbours, in a national context of low levels of undernutrition but low dietary diversity.
Social Capital	<ul style="list-style-type: none"> Information flows and trust are moderately high. Harvesters share strong internal group solidarity. However, formal Forest User Groups are entirely excluded from value chain governance, leading to severe member disillusionment over perceived responsibilities without rights.
Living Conditions	<ul style="list-style-type: none"> Exceptional seasonal incomes heavily support rural livelihoods. Funds are used for survival (debt repayment, food clothing), but also widely for investment in pastoralism (livestock and haymakers) and social mobility (university fees, apartments).

Is the value chain environmentally sustainable?

The environmental impacts of the pine nut VC are measured through Life Cycle Assessment (LCA) considering three areas of protection: resource depletion, ecosystem quality and human health. LCA results also show the VC's impact on climate change.

Total impact on areas of protection

The environmental impacts of the Mongolian pine nut VC are highly concentrated at the harvesting stage, while downstream activities remain limited in scope and intensity. As a non-timber forest product sourced entirely from natural subalpine taiga ecosystems (1,500-2,400 m), with 65% of the resource located in protected areas (of which 92% within the Khan Khentii Strictly Protected Area), the VC has no plantation base and relies exclusively on natural forest dynamics.

Processing activities including cone crushing, shelling, and basic transformation are technically simple, low-energy, and generate limited impact. Transport represents the main environmental impact beyond forests, mainly through carbon emissions, though these remain marginal at the national scale compared to forest fires or coal combustion for household heating.

Mongolia is unique in its use of heavy wooden hammers (up to 30 kg) to dislodge cones from standing trees. Repeated striking, often several times per season on the same trees, causes bark and stem damage, mechanical stress, and likely reduces long-term tree vitality and cone productivity (something to be confirmed through further study). These impacts are amplified by strong competition among harvesters, leading to early harvesting of immature cones, which require more force to remove and increase tree damage.

Weak governance exacerbates these pressures. Illegal harvesting remains widespread, while quota systems rely on limited and non-representative sampling (often a few dozens of trees across thousands of hectares), resulting in unreliable estimates of sustainable yield.

Biodiversity

Biodiversity impacts are significant, and closely linked to harvesting intensity. Pine nuts are collected in Siberian pine pure stands, where cone removal directly reduces food availability for wildlife. Unlike surrounding coniferous species which rely on wind dispersal, Siberian pine depends entirely on animal-mediated seed dispersal, and its seeds are a major food source for mammals and birds. At the same time, Siberian pine regeneration relies heavily on the Siberian nutcracker (*Nucifraga caryocatactes macrohynchos*), a specialized bird species whose population follows cone availability. By caching seeds, nutcrackers ensure dispersal and support regeneration. Maintaining sufficient cone availability is therefore essential for both wildlife and long-term resource productivity. Yet this ecological relationship remains poorly understood among harvesters and forest managers.

Climate change threats

Beside the impacts of the value chain on the environment, environmental trends, especially climate change, pose risks to the value chain. Mongolia has experienced approximately +2.5°C

warming over the past 80 years, with major impacts on forest ecosystems. Increased forest fires combined with permafrost thaw and drought are reducing forest resilience. Seasonal changes, including temperature fluctuations during pollination periods, are already disrupting cone production cycles and affecting supply stability.

Forest fires are particularly critical, having already affected approximately 28% of Mongolia's forest area. Siberian pine, a late-successional and fire-sensitive species, regenerates poorly after disturbance, while Siberian larch (*Larix sibirica*), already dominant in national forests, is more resilient. This creates a structural risk of long-term transition away from Siberian pine-dominated forests.

At the same time, awareness and enforcement gaps persist: only around 40% of forest users identify fires as human-induced, compared to 90% in official data, indicating insufficient prevention and limited awareness in remote areas.

Although Siberian pine is widespread globally, Mongolian populations are more vulnerable. The species is classified as rare and listed as threatened nationally, with populations likely to contract under climate change, becoming increasingly confined to high-altitude refuge zones.

Forest management and regeneration gaps further compound these risks. Siberian pine accounts for less than 1% of nursery production and planting programmes, which prioritise faster-growing species. Given slow natural regeneration in high-altitude environments, this creates a structural limitation in restoring degraded stands for productivity losses.

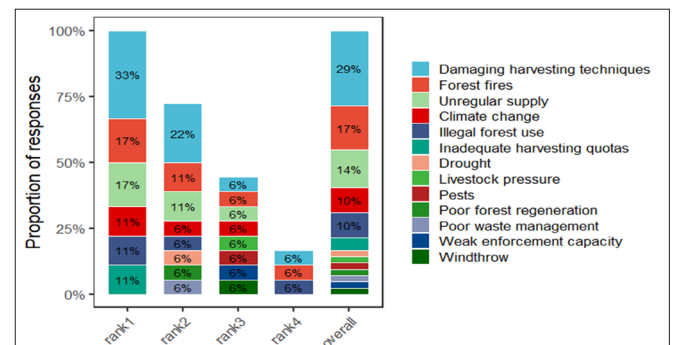


Figure 5 Interviewee's perceived threats to the pine nut value chain across different ranks of importance (Rank1 = first mentioned, Rank4 = fourth mentioned, overall = all responses combined). Unlabeled bars represent values <5%.

Overall, the Mongolian pine nut value chain has a low direct environmental footprint but is highly dependent on Siberian pine forest health, with most pressures concentrated at the harvesting stage. Climate change and weak governance are the main threats, while limited monitoring and regeneration further increase vulnerability. Without stronger forest-level management, the long-term sustainability of the value chain remains at risk.

Main findings and recommendations

STRENGTHS	WEAKNESSES
<ul style="list-style-type: none"> Large Siberian pine resource base (612,000 ha) with strong regional concentration (Khentii and Khövsgöl Mountains regions) High natural yields and valuable, globally demanded product (premium kernel market) Well-established traditional knowledge and widespread participation in harvesting Processing capacity exists in Ulaanbaatar, including emerging high-end firms Strong export orientation with reliable demand from China and niche demand in premium markets 	<ul style="list-style-type: none"> Highly irregular and cyclical yields, creating unstable supply Significant informality and weak alignment between regulations and actual harvesting practices. Limited domestic value addition: most exports remain bulk kernels Poor data availability on yields, harvest volumes, and trade flows. Fragmented supply chain with weak bargaining power among harvesters Heavy dependence on wild forests; no plantation or managed production systems Climate change
OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> Development of premium, branded, certified, or organic products for Europe, USA, Korea, Japan. Strong potential for by-product utilisation (shells, cone residues) in biochar, extracts, oil. Upgrading of processing capacity and diversification (retail packaging, oil, nutraceuticals). Improved quota governance and traceability systems could enhance sustainability and market access. Potential for community-based forest management, stewardship roles for FUGs, and restoration jobs. 	<ul style="list-style-type: none"> Increasing pressure on forests from informal and over-quota harvesting. Policy misalignment and administrative complexity may undermine compliance and long-term sustainability. Dependence on a single dominant export market (China) exposes processors to price and demand shocks. Climate variability and forest health issues will exacerbate yield fluctuations. Risks of market capture by intermediaries or processors, limiting benefits for rural harvesters.

Recommendations

- To ensure sustainable harvesting and ecological resilience, the government must implement strict resource monitoring using randomized, permanent plots and robust, standardised forest inventories to accurately track cone yields, decoupling quotas from local fiscal targets. Policy should promote low-impact harvesting by enforcing harvesting calendars, reducing tree damage, and disseminating ecologically sensitive practices at scale. Furthermore, authorities should institute 3-5 year rotational harvesting zones and permanently protect at least five seed-bearing trees per hectare to sustain the Siberian Nutcracker and natural regeneration. Reforestation strategies must be urgently revised to scale up Siberian pine nursery production, using value chain revenues to fund high-altitude restoration protected from livestock.
- In terms of forest governance, lawmakers must harmonize deeply contradictory legal frameworks that simultaneously ban commercial harvesting in Special Protected Areas yet tax and sanction it via state quotas. Institutional reforms should empower marginalized Forest User Groups by granting them formal harvesting and monitoring rights, replacing their

current disenfranchisement. Development partners should direct funding towards capacity-building at harvester, soum and ISFU level and inter-agency coordination to prevent illegal.

- For sustainable investments and financing, EU Delegations and development finance institutions (DFIs) must exclusively target value upgrading rather than volume expansion. Investments should centralize high-end processing, branding, and export logistics in Ulaanbaatar to leverage economies of scale, while supporting localized, sustainable upstream aggregation in rural hubs. Finally, strategic support should diversify premium export markets to reduce monopsony dependence on bulk Chinese buyers. This requires upgrading Sanitary and Phytosanitary (SPS) compliance and securing organic certifications to access premium retail markets in the EU, Japan, and Korea – while not neglecting incremental improvements in marketing to China and domestically.
- With these measures in place, the value chain can transition toward a more sustainable and climate-resilient model, securing both forest ecosystem integrity and long-term economic viability.

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