Transforming High Altitude Barren Lands into Climate Resilient Assets and Oases

Student Name: AYSE UMAY BAHCIVAN

School: ROBERT COLLEGE

Country: TURKEY

ABSTRACT

This study investigates the ecological and economic reclamation of marginal landscapes at an elevation of 2,000 meters in Elbistan, Turkey. Following the 2023 earthquakes, the project aimed to transform barren, rocky terrain into a productive orchard for the EU-protected Malatya Apricot using a sustainable dry farming model. The methodology integrated the use of raw leonardite, an industrial byproduct from the Afşin-Elbistan Thermal Power Plant, alongside elemental sulfur and targeted nutrient management to enhance soil organic matter and rehabilitate high alkaline terrain, reducing soil pH from an initial range of 8.0–9.0 to approximately 7.0. Supported by precision mechanical tillage and a zero-irrigation strategy, the project scaled from 500 to 10,000 trees through a collective family labor model. Key results demonstrate a 98% sapling survival rate despite calcium carbonate levels ranging between 25% and 40%, and successful protection against the catastrophic spring frosts of April 2025. While lowland orchards suffered total crop failure, the sub-alpine microclimate delayed blooming by four weeks, securing the saplings' physiological development and future productive potential. Furthermore, the direct-to-source utilization of leonardite and organic amendments mitigated the carbon intensity compared to conventional soil amendments. The findings conclude that integrating circular economy principles allows for the successful cultivation of high value crops in marginalized upland areas, proving that climate resilient and water efficient agriculture can foster community resilience and food security under extreme environmental conditions.

INTRODUCTION AND GOAL

The Southeastern Anatolia region, particularly Kahramanmaraş and Malatya, faces critical socio-economic challenges following the 2023 earthquakes. Traditional lowland apricot farming is increasingly unsustainable due to climate change and heavy water demands estimated at 850–1,200 mm annually (Malatya Apricot Research Institute, 2017). In contrast, marginal upland terrains above 1,500 meters remain underutilized due to high lime content, alkalinity, and difficult accessibility. However, these high-altitude landscapes offer unique phenological advantages.

Malatya apricots, protected by EU Geographical Indication (2017), require approximately 1,000 hours of chilling below 7.2°C to ensure yield stability (Asma, 2011). The project site naturally meets this chilling requirement while extreme diurnal temperature fluctuations enhance sugar accumulation, measured as Brix value, improving fruit quality (Akin et al., 2008). Furthermore, low humidity at high elevations acts as a natural barrier against fungal pathogens like Brown Rot (Monilinia laxa), facilitating organic production without chemical intervention.

The 2023 earthquake highlighted the geological resilience of these terrains; seismic amplification is significantly lower in hard rock structures compared to the alluvial soils of city centers (Güllü et al., 2024). Post-disaster migration to remote mountainous settlements and traditional summer pastures has improved rural infrastructure, enabling machinery access to previously inaccessible sites.

To overcome soil limitations, this project utilizes leonardite, an industrial byproduct from the nearby Afşin-Elbistan Thermal Power Plant, in synergy with elemental sulfur and integrated nutrient management. Rich in humic and fulvic acids, leonardite stabilizes nutrient uptake in high-lime environments and enhances carbon sequestration, transforming a low-cost industrial waste into a vital agricultural asset (Moraes et al., 2017). This research evaluates the feasibility of reclaiming these marginalized upland areas through dry farming as a strategic model for regional agricultural recovery.

GOAL OF THE PROJECT

The primary objective of this project is to transform barren, high-altitude land at 2,000 meters currently categorized as marginal and high-risk, into a productive dryland orchard. By employing integrated edaphic reclamation strategies, the project seeks to create a climate-resilient ecosystem capable of sustaining high value crops. Beyond ecological innovation, it aspires to turn rocky terrain into a living oasis, reclaiming the productive capacity of ancestral lands and fostering community-led economic recovery following the 2023 earthquakes.

This project carries a strong personal and social motivation. Importantly, the site is not a uniform plain but a fragmented high-altitude terrain. Between rocky outcrops, centuries of erosion have deposited fertile soil pockets. These scattered micro-zones provided the foundation for orchards across thousands of decares, making cultivation possible not on a continuous field but on dispersed fertile patches integrated into the rocky landscape. A century ago, my forefathers cultivated small plots of wheat in these lands under harsh conditions, laboriously collecting stones by hand to prepare the soil. Although they lived here for generations, the extreme climate and lack of sustainable methods eventually forced them to abandon the land. Later attempts also failed due to soil alkalinity and economic infeasibility. After the recent earthquakes, many of my relatives lost their homes and jobs in the city. This project aims to give them hope to return to their homeland, reclaim ancestral soil, and turn climate challenges into opportunities for renewal.

The study seeks to answer the following fundamental questions:

1. How can the synergistic application of elemental sulfur and the humic and fulvic acids in leonardite improve the pH balance and nutrient availability of soil with extremely high lime content? (Moraes et al., 2017)
2. At high altitude, apricot trees bloom later. How can this “late blooming” characteristic be used as a strategic advantage to bypass the increasing frequency of spring frosts caused by climate change? (Asma, 2011)
3. Apricot trees (*Prunus armeniaca*) normally need about 1,200 mm of water annually. How can they survive on only 450–500 mm of natural rainfall, without external irrigation?(FAO, 2023)

Photo: Dark brown patches are fertile soil pockets accumulated between rocky outcrops.

Hypothesis

In high-altitude marginal lands, by using late-flowering genotypes and improving soil structure, it is possible to create a high value added agricultural model where natural rainfall is sufficient to meet plant water needs. External irrigation would not be required, the system would be climate resilient, and it could support both ecological restoration and the economic recovery of local communities after earthquakes.

METHODOLOGY

The project is rooted in a rigorous preliminary research phase that began before the 2023 disaster. Feasibility analysis was initially conducted in 2021 to determine the nutrient profile and alkalinity of the marginal land. These early results, which showed high pH and calcium carbonate levels, allowed for the pre-planning of a leonardite and sulfur based soil amendment strategy. While the project was in its conceptual and testing phase in 2022, the 2023 earthquakes accelerated the transition from a research pilot to a large-scale social and economic recovery model.

This study consisted of different stages and each detailed below;

Site Selection, Land Reclamation and Soil Analysis

The study area was selected on a steep, fragmented hill ranging from 1500 to 2000 meters in altitude. The terrain is not a uniform plain but a mosaic of rocky outcrops interspersed with scattered soil pockets formed by centuries of erosion. These fertile micro-zones, though dispersed, historically supported cultivation and now provide the foundation for dryland orchard establishment. These soils had long been considered “uncultivable” due to their high lime content and rocky structure.

The project was not limited to privately owned lands. Idle state owned lands in the region were also legally leased from the government and brought back into agricultural use.

During land preparation, thousands of tons of stone were removed. Instead of discarding them, the stones were reused for traditional stone house construction, terracing, and micro-watershed creation, ensuring that the site’s natural topography was preserved.

Photo: Leonardite added to the holes

Soil samples from different points across the site were analyzed in university-approved laboratories. The results confirmed that the soil had a high pH of ~8 and a lime content of ~20%, while organic matter was insufficient. Comprehensive soil analysis confirmed that organic matter was critically insufficient. To address these constraints, a dual-action reclamation strategy was implemented:

Elemental Sulfur, applied to neutralize alkalinity and facilitate nutrient uptake. Leonardite, rich in humic and fulvic acids, was integrated into each planting hole to improve the soil's chemical stability and increase water retention capacity.

The study site includes a historical water well at the center of the plateau, likely a Roman or Byzantine cistern designed to collect rain and snow in this stream-scarce area. Its structure, together with the centuries-old plane tree and nearby burial mounds, highlights the long human presence and cultural significance of the land. These features were carefully preserved during reclamation, ensuring that ecological restoration coexists with heritage protection.

Infrastructure and Energy Solutions

Logistics: Due to the site's remote location, an off-grid infrastructure was required. A highly insulated stone house was constructed using local stones. Compared to prefabricated structures in the region, the stone house reduced costs by 60%. Its high thermal mass provides passive climatization, saving energy under extreme weather conditions. Beyond structural efficiency, multi-layered safety protocols were integrated: pheasant breeding was introduced to biologically control the yellow scorpion population, while cobalt blue pigments applied to door and window thresholds created an optical barrier. This specific color is perceived by scorpions as flame-like, triggering avoidance behavior and ensuring a safe, chemical-free living environment.

Energy: To eliminate carbon emissions and achieve energy independence, an off-grid solar energy system was installed. Solar power supplies all essential on-site operations, including groundwater extraction from wells, daily residential needs, and the charging of cordless agricultural and construction equipment.

Water and Resource Management: Water resources in the region are extremely limited. The capacity of the ancestral well is only 3 tons. It is purified through reverse osmosis and carbon filtration systems and used exclusively for hygiene and drinking purposes.

Photo: Stone House, Solar Panels

Investment and Mechanization Strategy

Machinery and equipment; This project is an example of social entrepreneurship where the student project leader's scientific vision merges with their family. While the strategic borrowing and mechanization were undertaken by the family, the student provided the scientific design and coordination; this investment plan created the necessary tillage capacity to maintain the moisture balance. By leveraging their technical resources and mechanization tools such as tractors and tillers, they convinced neighboring families and led a collective development model for 10,000 trees, thus creating a regional benefit.

Sapling Selection and Risk Management: Traditional commercial sapling procurement was not preferred due to the adaptation problems experienced by lowland-adapted saplings and their high costs. Instead, small, 1-2 year old saplings with greater adaptation ability, sourced from local sellers, were preferred. This choice allowed the saplings to develop their root systems faster with limited water resources and created an 70% cost advantage compared to large commercial saplings. The selection of small saplings optimized the root stem balance, increased the survival rate in harsh climatic conditions, and proved the economic sustainability of the project. This strategic decision resulted as 98% survival rate of saplings.

Photo: 1-2 year old saplings

The selected Hacıhaliloglu and Kabaası varieties are known for their cold resistance, high yielding rates and high dry matter content (25-30% Brix) make them ideal for drying. The day-night temperature difference maximizes the sugar concentration of this variety, significantly improving fruit quality compared to lowland cultivation.

Project Timeline Table xx and Phased Implementation: The implementation phase of the project was carried out through a three-year strategic expansion to test adaptation to the challenging conditions of this specific microclimate.

Year	**Phase**	**Key Milestones**	**Strategic Objectives**
2022	Research & Pilot	Soil laboratory analysis; University consultations; Financial feasibility study; Soil enrichment with leonardite and sulfur; Trial planting of 500 saplings.	Establish scientific viability and determine soil amendment requirements for altitudes above 1500 m.
2023	Infrastructure & Resilience	Acquisition of an 80HP tractor; Construction of a stone house for logistics; Installation of an electrical system; Planting of 1,000 saplings; Initiation of beekeeping activities.	Build physical infrastructure and test operational capacity in the immediate post earthquake context.
2024	Social Scaling	Acquisition of manual tillers; Planting of 1,500 saplings; Inclusion of four local families; Expansion to 10,000 trees; First symbolic fruit yield (~150 kg).	Transform the individual venture into a collective family model to strengthen regional socioeconomic resilience.
2025	Climate Test & Survival	Severe frost event in April; Orchards at lower altitudes suffered crop failure; Project site trees survived but did not bear fruit.	Demonstrate microclimate advantage and resilience, proving the site as a climate safe haven for the EU-protected Malatya Apricot.

Table 1: Project Timeline throughout 2022-2025

Following the earthquake disaster, the project was expanded to include 4 local families (relatives) who established their own production areas, bringing the total population to 10,000 trees. While family solidarity is prioritized in the current operational process, the plan is to employ seasonal workers during the harvest season, aiming to transform the project into a regional development and employment model.

Planting and Zero-Irrigation Strategy

Phenology Management: Regional meteorological data were used to analyze frost risk and temperature variations (TSMS, 2025). 10m x 10m intervals layout applied to maximize sunlight exposure and allow for air circulation. The soil was tilled twice a year to break up evaporation channels. This technique forms the basis of moisture conservation strategies in low-rainfall regions (Widstoe, 1911).

While campaigns against the global water crisis often focus on reducing individual household consumption, the agricultural sector, which consumes 70% of freshwater resources, remains outside these discussions.(FAO, 2020; World Bank, 2022) .

This project goes beyond household water savings by advocating a Zero-Irrigation model that eliminates dependence on pumped water in agriculture. Traditional orchards require about 3.5 tons of water per tree annually nearly 35 million liters per season for 10,000 trees creating heavy energy and financial OpEx costs. Our model replaces this infrastructure with strategic mechanical tillage, consuming only ~4,500 liters of diesel fuel per season for 1,000 decares.

Compared to the massive energy demand of pumping millions of liters of water, this represents a 90–95% reduction in the orchard's energy footprint.

By conserving 35 million liters of water annually the equivalent of 16 Olympic sized swimming pools, the project demonstrates truly sustainable and scalable water management for water-stressed regions

Ecosystem Engineering and Social Innovation

The project site's elevation and the weakness of the surrounding natural forest/vegetation limit the number of natural pollinators. Although apricot trees are self fertile, research confirms that honeybees significantly enhance fruit set and quality through cross-pollination (Eisikowitch & Lupo, 1989).

To address this ecological constraint, a small-scale beekeeping operation was initiated with a single hive and naturally expanded through swarming. By the third year, the beekeeping activity had grown to eight hives, yielding 200 kg of honey. Importantly, this honey was not commercialized but shared among all relatives who contributed to the demanding field operations, thereby strengthening social solidarity.

This beekeeping activity, initiated in the project area, is not a source of supplementary income but a deliberate step in ecosystem engineering. It directly enhances pollination success and improves fruit yield by transforming ecological innovation into a social benefit.

Photo: Taking care of beehives (2023)

Protection strategies balance ecological sustainability with economic efficiency. Bordeaux Mixture, a traditional copper-sulfate and lime fungicide, is applied during dormancy to prevent fungal and bacterial infections.

Wildlife risks, particularly rabbit damage during heavy snow cover, are mitigated by wrapping sapling bases with protective mesh. This ensures survival without harming local fauna, maintaining a wildlife-friendly coexistence.

Soil Improvement Strategy and Industrial Symbiosis**:** The soil improvement strategy was formulated based on comprehensive laboratory soil analysis reports. These reports identified critical deficiencies in organic matter and high alkalinity as the primary barriers to cultivation. Following expert recommendations, a high dosage application of Leonardite was integrated into the reclamation process.

Based on the soil analysis reports, the application of leonardite in conjunction with elemental sulfur served three critical functions:

1. Humic acids acted as natural chelating agents, making nutrients bioavailable despite the high lime content.
2. Improved the soil's water retention capacity, which is the technological backbone of our Dry Farming model.
3. Stimulated microbial activity, initiating long term ecological recovery.

Leonardite is a mineral extremely rich in organic matter, formed by the oxidation under pressure of millions of years old, incompletely carbonized plant and animal remains during the lignite coalification process. In open pit lignite mines like the Afşin-Elbistan Thermal Power Plant used in our project, this material is found as a layer directly above economically valuable coal seams. This layer, which reduces coal combustion efficiency and is an industrial waste burden that needs to be disposed of, is one of the world's richest natural sources of humic and fulvic acids from an agricultural perspective (Moraes et al., 2017). Through cooperation with local administrations, raw leonardite was obtained directly from the mine site at minimal cost, transported to the project area without industrial processing. This Direct-to-Source model reduced input costs and carbon footprint up to 90% compared to commercially processed humic acid products. Applied to the soil, the combined application of elemental sulfur and leonardite balanced the excessively high lime content and alkalinity, enabling nutrient absorption and improving water retention. It became a key technological component in the success of our model, proving that discarded industrial waste can be transformed into a vital agricultural asset in post-earthquake rehabilitation.

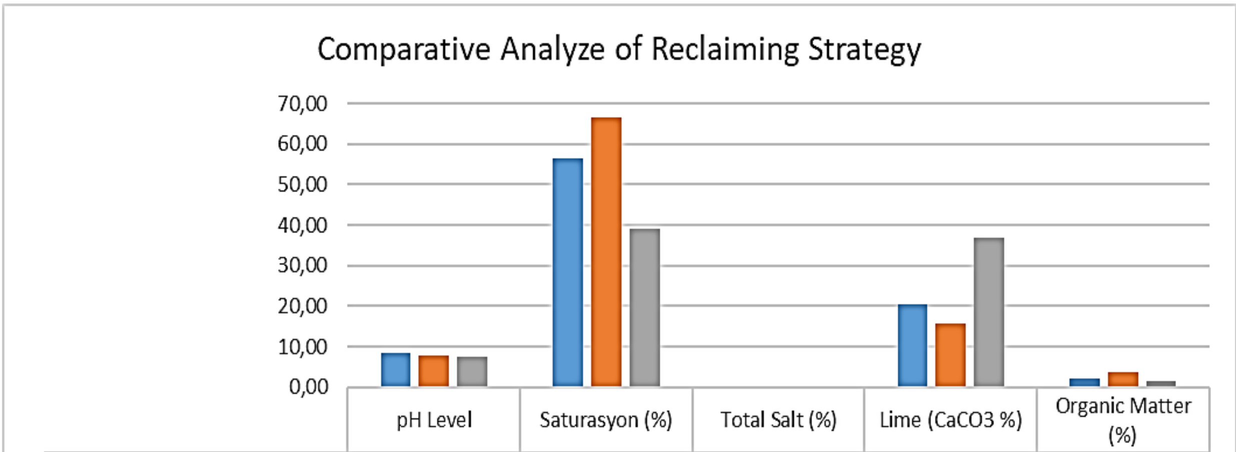
Community Engagement and Social Impact: The project's success is based not only on technical innovation but also on strategic leadership and a visionary social entrepreneurship model. The project initiator first proved the leonardite-supported and water-efficient model on their own plot; then, using this success as a proof of concept, persuaded four families in the surrounding area to adopt the model. In this process, the initiator facilitated knowledge transfer and shared technical resources (machinery, water purification, leonardite supply, etc.), enabling the project to expand to a regional scale. This leadership transformed an individual agricultural experiment into a collective solidarity and development model that triggered social recovery after the earthquake

Economic Framework: The project’s economic foundation rests on resource efficiency and strategic asset management. By reclaiming marginal uplands, ecological challenges are converted into productive agricultural assets with minimal debt exposure. A key driver of financial sustainability is the zero Irrigation policy, which eliminates costly water infrastructure and pumping, reducing annual operating expenses by ~70% compared to conventional orchards. Capital expenditures were limited to essential items: an 80HP tractor, tillers, 10,000 saplings, protective mesh, land preparation, and soil amendments including locally sourced leonardite, elemental sulfur, and university recommended fertilizers, while annual operating costs remain modest. Altogether, the direct capital outlay amounts to $106,700, a remarkably low figure for establishing a 1,000-decare orchard ecosystem.

5. RESULTS

Data obtained in the first phase of the project confirm the technical and environmental success of the implemented methodology. The findings are grouped under the following main headings:

1) Soil Stabilization and Tree Survival: It is observed that the combined application of leonardite, elemental sulfur, and recommended fertilizers resulted in a 98% sapling survival rate. Despite the initial high lime content, the trees exhibited healthy root development and no signs of chlorosis (iron deficiency), confirming that sulfur effectively managed pH levels while leonardite's humic and fulvic acids improved nutrient bioavailability. This synergistic approach stabilized soil chemistry and increased water retention, proving its effectiveness in reclaiming marginal soils.
2) Comparative Analyze of Reclaiming Strategy: To objectively demonstrate the impact of our land reclamation strategy, we have selected three pivotal soil analysis reports that represent the distinct lifecycle phases of the 1,000 decare orchard. This comparative approach allows us to move beyond static data and observe the dynamic response of the soil to our interventions:



	pH Level	Saturasyon (%)	Total Salt (%)	Lime (CaCO3 %)	Organic Matter (%)
Raw Baseline 2021 Sept	8,41	56,32	0,02	20,29	2,04
Active Management 2022 July	7,68	66,66	0,04	15,74	3,58
Dormancy/Current 2026 Feb	7,58	39,00	0,03	36,78	1,43

Graph 1: Comparative Analyze of Reclaiming Strategy

-The Raw Soil/ Baseline (Sept 2021): This report captures the soil in its original, untreated state characterized by extreme alkalinity and high lime content, providing the benchmark for all subsequent improvements.

-*The Active Management Phase (July 2022):* Selected to demonstrate the immediate efficacy of the intensive rehabilitation program during the peak growing season.

-*The Dormancy/ Current (Feb 2026):* This current report represents the soil's "resting" state at the end of a production cycle, before any seasonal maintenance has begun. It is crucial for proving the long-term, sustainable chemical stability achieved by the project.

- *pH Level Analysis*: The reduction from a highly alkaline 8.41 to a near-neutral 7.58 is the project's primary technical achievement. The 2026 data confirms that the cumulative application of elemental sulfur has created a lasting buffering effect. Even during the dormancy period, the pH remains within a range that prevents nutrient lock-up, ensuring that minerals remain bioavailable for the upcoming spring surge.

- *Active Lime (CaCO3) Analysis:* The shift to 36.78% in the 2026 dormancy phase reflects the inherent geological nature of the region. However, the critical takeaway is that while lime content is high, its negative impact is neutralized by the stabilized pH. This proves that our methodology manages the effects of lime effectively, preventing the typical lime induced chlorosis .
- *Organic Matter Analysis:* The surge to 3.58% in 2022 highlights the immediate impact of leonardite and organic fertilization. The subsequent decrease to 1.43 % in Feb 2026 is an expected biological result; it represents the organic fuel consumed by the 10,000 saplings during the growing season. This confirms the soil is a living, active ecosystem that requires periodic organic replenishment during active cycles.
- *Saturation Analysis:* The decrease to 39.00% indicates a shift towards a Sandy Loam characteristic during the dry/cold months. This is ideal for our dry farming model, as it prevents waterlogging during winter snowmelt while the residual leonardite maintains micro moisture pockets around the root zones, ensuring survival without artificial irrigation.
- *Total Salt Analysis:* Remaining consistently between 0.02% and 0.04%, the soil is classified as non-saline. This confirms that our soil amendments do not increase salinity, maintaining a healthy osmotic balance for the roots even under the low water conditions of the Elbistan uplands.

3) Frost Risk: The 2000 meter microclimate naturally delayed the flowering period of the trees by approximately 3-4 weeks compared to the Malatya plains. This phenological delay proved to be a critical survival advantage during the catastrophic frost events of April 2025. While apricot orchards in the Malatya city center and lower altitudes suffered severe flower loss and crop failure due to early season frost, our trees only began blooming in late April, completely bypassing the frost window. In 2024, a portion of the initial 500 test trees produced their first symbolic fruits, approximately 150 kg across the orchard. Although the trees were biologically too young for commercial harvest, this outcome confirmed the site's resilience. In 2025, the trees did not bear fruit, which is expected at this juvenile stage, but their survival through severe frost demonstrated that the project site not only meets chilling requirements but also functions as a climate safe haven, protecting the genetic potential of the EU-protected Malatya Apricot against increasingly unpredictable spring frosts.

4) Mechanical Tilling vs. Irrigation: By applying a zero-irrigation policy and preserving ancient soil moisture through limited mechanical tillage, the project avoided pumping 35 million liters of water per season, achieving major energy and cost savings. (This figure is based on a conservative agronomic benchmark of 3.5 m^3 annual water requirement per tree for 10,000 apricot saplings in semi-arid conditions.)

5) Carbon Sink : Planting 10,000 apricot trees has created a significant carbon sink. A mature fruit tree sequesters an average of 22.6 kg of CO_2 annually (Toader et al., 2019). At full maturity, the orchard will sequester approximately 226 tons of CO_2 per year. According to EPA standards, this is equivalent to offsetting the emissions of a typical passenger car traveling over 1.1 million kilometers (EPA, 2023).

Category	Data / Computation	Ecological Response / Note
Total Number of Trees	10,000 (Prunus Armeniaca)	High-altitude compatible local genotypes
Annual CO_2 Absorption	~226 tons per year	At maturity, each tree absorbs ~22,6 kg CO_2 (Toader et al., 2019)
Carbon Offsetting	Equivalent to 1,000,000 km of vehicle travel	Equal to 27 full trips around Earth by a passenger car (EPA, 2023)
Carbon Emissions	0 (Net Zero)	Zero-irrigation eliminates pumping energy; off-grid solar for site operations

Table 2:Ecological Footprint & Carbon Sequestration Analysis

6) Strategic Nutrient Management and Circular Economy: The project’s foundational strategy utilizes locally sourced leonardite from the Afşin-Elbistan basin to overcome the chronic nutrient lock-up typical of high-calcium soils. Rather than relying on carbon intensive synthetic fertilizers which often become insoluble in high-pH environments, leonardite acts as a natural chelator and stabilizer. This hybrid approach ensures that essential minerals remain bioavailable to the saplings, significantly lowering input costs while minimizing the carbon footprint associated with conventional chemical dependency.

7) Combined with zero-irrigation and optimized fuel consumption (~4,500 liters annually for the entire 1,000 decare site), the project achieves a Net Carbon Negative status. Precision tillage reduces the energy footprint by eliminating irrigation pumps, positioning the orchard as a vital ecological buffer for the region.

8) Harvest: Despite being the first year of production, a sample harvest of 150 kg at 2024 showed fruit quality above expectations, with clear signs of high sweetness. Formal Brix measurements will be conducted in collaboration with İnönü University to validate sugar content against Malatya apricot standards. For 2025 no harvest due to catastrophic extreme frost, but survival confirmed.

9) The effectiveness of the dry farming and mechanical propulsion strategy has been measured. Electricity provided through solar panels has ensured an uninterrupted water and electricity supply for household use and the construction process, with zero carbon emissions.

10) Employment : The active participation of dozens of relatives of earthquake victims in this process reduced dependence on state aid and enabled the local population to become productive again on their own land. Active employment was provided to relatives of earthquake victims directly affected by the earthquake during the planting of 10,000 saplings, the clearing of stones from the land, and infrastructure works. This process is not only physical labor but also a collective rehabilitation and a project of re-establishing a foothold on the ancestral lands.

Impact Category	*Traditional Lowland Parameters*	*High-Altitude Oasis Model*	*Net Strategic Gain / Results*
Water Consumption	*3.5 – 4.0 Tons / tree (Annual)*	*~0 Tons / tree (Dry Farming)*	*100% Water Conservation*
Irrigation Energy	*High (Electric/Diesel pumping)*	*Zero (Gravity & Natural Rain)*	*100% Energy Saving (Fuel/Elec.)*
Nutrient Management	*100% Synthetic Fertilizer*	*Leonardite + 40% Mineral Support*	*60% Reduction in Chemicals*
Pest Control Energy	*6-8 Synthetic Spraying Cycles*	*Only Bordeaux Mixture (Organic)*	*100% Synthetic Pesticide-Free*
Flowering & Frost	*Early Bloom (Vulnerable)*	*4-Week Bloom Delay*	*Frost-Safe (2025)*
Soil Value & Safety	*Alluvial (Seismically Fragile)*	*Barren/Rocky (Seismic Resilience)*	*Disaster-Resilient Land Asset*
Product Value (Brix)	*22–24% (Bostan, 2009)*	*Higher Dry Matter Potential (Asma, 2007)*	*Premium Quality & Export Potential*
Labor Energy	*High (Continuous Irrigation/Mow)*	*Minimized (Low maintenance)*	*Significant Operational Efficiency*

Table3 :Comparative Analysis of Resource Conservation and Efficiency Results

The project leader orchestrates both the technical and social architecture of the venture through continuous fieldwork conducted every summer. This process is not merely a mechanical agricultural activity; it is a collective learning process shared with earthquake affected relatives and the younger generation. Central to this social sustainability is the preservation of local traditions, such as the harvesting of thistle gum (Gundelia). Once a natural treat born of necessity for local children, this practice is now preserved as a nostalgic cultural value, reconnecting the younger generation with their heritage as they collect it using traditional methods. Additionally, insect populations in the field are monitored as a bioindicator; these observations demonstrate how the use of leonardite and pesticide free dry farming supports both above ground and below ground biodiversity. This leadership model enhances the youth's connection to the land by transforming agricultural production into an educational and engaging social activity, thereby fulfilling the project's goal of long term social resilience.

Photo: Leading the land reclamation project, walking through what was once barren land, now a thriving apricot orchard

11) Financial & Ecological Overview;The project required a total investment of $*106,700*. At full maturity, annual revenues are projected between $2.2M–$3M, ensuring rapid recovery of costs. Ecologically, the orchard absorbs ~200 tons of CO_2 per year, offsets the equivalent of 1 million km of vehicle travel, and achieves net zero emissions through solar energy. Together, these results demonstrate both strong financial sustainability and significant environmental impact.

Category Type	Item	Description	Actual/ Estimated Cost (USD)
CapEx	*Biological Assets*	*10,000 Saplings @ $2/each*	*$20,000*
CapEx	*Machinery*	*80HP Tractor ($31,000) + Manual Tillers ($2,200)*	*$33,200*
CapEx	*Infrastructure*	*Protective Mesh + Land Preparation*	*$15,000*
OpEx	*Annual Fuel*	*4,500 Liters annually x 3 years (Tillage and Maintenance)*	*$16,500*
OpEx	*Annual Inputs*	*Hybrid Nutrient System: Local Leonardite + Elemental Sulfur + Targeted Synthetic Fertilizers & Bordeaux Mixture (x3 years)*	*$12,000*
OpEx	*Annual Labor*	*Pruning and Protective Application (2 times annually)*	*$10,000*
TOTAL	*Investment*	*Direct Capital Outlay*	*$106,700*

Table 4:Investment and operating costs are summarized at the table.

Stage	Yield per Tree	Total Yield (Fresh)	Total Yield (Dried)	Price Range (USD/kg)	Projected Revenue (USD)
Initial Yield (Year 1)	*–*	*150 kg total*	*negligible*	*–*	*–*
Early Maturity (Years 6–7)	*40–50 kg*	*~400–500 tons*	*~100 tons*	*$6–8*	*~$0.6M–$0.8M*
Full Maturity (Years 10–12)	*~150 kg*	*~1,500 tons*	*~375 tons*	*$6–8*	*~$2.2M–$3M*

T**able5 :Revenue projections by stage are shown at the table**

12) Economic and Social Impact: Project's greatest achievement is the transformation of a barren piece of land, considered a "dead investment," into a social lifeline in the aftermath of the earthquake.

13) This project represents a paradigm shift for Malatya apricots. Production, traditionally carried out in low-lying plains, is now threatened by climate change and the water crisis. With rising education levels and the widespread adoption of technologies like solar energy, previously inaccessible lands at 2,000 meters are no longer an obstacle; they are an advantage thanks to late flowering, high chilling conditions , and low disease pressure.

6. DISCUSSION

The results show that high altitude marginal lands can be transformed into efficient carbon sinks and production areas with the right techniques. The high survival rate of saplings demonstrates that leonardite can effectively stabilize soils with extreme lime and alkaline conditions. This outcome confirms earlier findings that humic and fulvic acids improve nutrient uptake and water retention (Moraes et al., 2017). Beyond technical success, the use of leonardite at symbolic costs illustrates how industrial byproducts can be revalued as affordable agricultural inputs, offering a replicable model for post disaster rehabilitation.

The delayed flowering observed at 1500 2000 meters validates the strategic choice of late blooming varieties. Rather than simply reporting reduced frost damage, this result highlights how altitude specific phenology can be leveraged as a natural risk management tool. It supports Asma (2011) and İnönü University's studies, while also showing that climate change induced irregular frosts can be mitigated through varietal adaptation.

The adoption of mechanical tillage instead of irrigation is not only a technical adjustment but a paradigm shift. While results quantified water savings, the broader implication is that agriculture can contribute meaningfully to global water crisis solutions. This project challenges the dominant narrative that focuses on household consumption by demonstrating that eliminating irrigation in orchards can save millions of liters of water annually.

The orchard's projected carbon sink capacity of 200 tons CO_2 annually is significant evidence that fruit orchards can function as climate mitigation tools. This aligns with EPA (2023) and Toader et al. (2019), but the integration of solar energy and minimal fossil fuel use extends the contribution toward a carbon negative agricultural model. Economic strategies local sapling procurement, interest free mechanization, and reliance on family labor created a framework of social entrepreneurship where resilience was built through collective ownership.

Beekeeping's role goes beyond pollination efficiency. By filling the ecological gap of limited natural pollinators at uplands, it ensured fruit set while acting as a bio indicator of habitat health. Addressing post earthquake logistics on site with stone houses and solar energy minimized operational costs, ensuring that production is not interrupted during times of crisis. The consistency between field outcomes and İnönü University's scientific findings demonstrates that this project not only restores marginal lands but also confirms academic research in real world conditions.

FUTURE WORKS

The long-term vision of this project aims to bridge the gap between elevated production sites and international export standards. A significant bottleneck in the traditional apricot industry is the reliance on open-air sulfurization in tents, which often results in chemical residues and dust contamination, making the product unsuitable for premium global markets. To resolve this, the future phase of the project focuses on adopting advanced Solar Dehydration Cabinets, similar to the energy-efficient models developed by Inonu University.

These cabinets offer a superior alternative to traditional methods by providing a controlled, dust-free environment where the fruit can be dried to precise moisture levels using only solar energy. This technology preserves the natural color and high-Brix nutrient profile of the apricots without the need for excessive sulfur or water-intensive washing processes. By integrating these solar cabinets, the project will ensure that the fruit meets the strictest organic and food safety certifications from the moment it is harvested. This transformation from a raw agricultural site to a tech-driven production hub will maximize the Geographical Indication value of Malatya Apricots, establishing a scalable, chemical-free model for sustainable mountainous farming.

CONCLUSIONS

This study confirms that marginal high altitude lands can be reclaimed through integrated ecological and economic strategies. By combining soil improvement via leonardite and elemental sulfur, phenological adaptation, and a zero irrigation dry farming model, the project achieved an exceptional 98% sapling survival rate. The strategic avoidance of irrigation infrastructure and the substitution of expensive synthetic inputs with local industrial byproducts resulted in a cost efficient investment of 106,700 USD for 1,000 decares, saving 35 million liters of water annually.

Equally significant are the social dimensions. The reliance on collective family labor and the preservation of local traditions, such as thistle gum (Gundelia) harvesting, created a resilient social architecture. Especially following the 2023 earthquakes, this model provided a critical pathway for community rehabilitation and emotional resilience. Ultimately, this project provides a scalable carbon negative blueprint for climate resilient agriculture, proving that even the most extreme environments can be transformed into productive and socially empowering ecosystems.

Photo: The landowner, grandfather and uncle during the early pruning of apricot trees, protected with netting against rabbits and prepared to withstand cold weather, March 2022.

Photo:After a long but rewarding day of work, waiting with my relatives for a delicious meal to be cooked.

T.C.
İSTANBUL BÜYÜKŞEHİR BELEDİYESİ
ÇEVRE KORUMA VE KONTROL DAİRESİ BAŞKANLIĞI
Çevre Koruma Şube Müdürlüğü
Asya Yakası Çevre Laboratuvarı

İSTANBUL BÜYÜKŞEHİR BELEDİYESİ

TÜRKAK
Test
TS EN ISO/IEC 17025
AB-0287-T

İBB Ek Hizmet Birimleri Cevizli Mah. E-5 Güney Yanyol
Kartal /İSTANBUL Tel:0 216 586 56 74 Faks: 0 212 455 43 43
E-posta: andcevrelab@ibb.gov.tr

AB-0287-T
T26-34
2-26

TOPRAK ANALİZ RAPORU

Rapor Tarihi : 18.02.2026

RAPOR SAYISI : T26-34
TALEP EDEN ** : Mehmet BAHÇIVAN
ADRES ** : Dereağzı Mah. Ziya Gökalp Cad. Göktürk Sokak Aydınlar Sitesi 6H1 Beylikdüzü/ İstanbul
ÖRNEĞİN ALINDIĞI YER ** : Yalıntaş Mah. Elbistan/ Kahramanmaraş
ÖRNEĞİN ALINDIĞI TARİH ** : 11.02.2026
ÖRNEĞİN LABORATUVARA KABUL TARİHİ : 12.02.2026
ANALİZ BAŞLANGIÇ / BİTİŞ TARİHİ : 17.2.2026/ 18.2.2026
NUMUNE BİLGİSİ ** : 104 Ada 6 Parsel (Toprak Numunesi)
EKİMİ PLANLANAN BİTKİ ** : Kayısı
ALINDIĞI DERİNLİK ** : 30-40 cm
ŞAHİT NUMUNE BİLGİLERİ (X) Şahit numune mevcut () Şahit numune alınmamıştır

PARAMETRELER	OLÇU BİRİMİ	ANALİZ SONUCU	KULLANILAN ANALİZ METODLARI
SU İLE DOYGUNLUK	%	39,00	TS 8333:1990
pH		7,58	Saturasyon Çamuru İşletme İçi Metot A(P20)05/28.04.2025/02
EC	µS/cm	1041	
TUZ	%	0,026	TS 8334:1990
KUM ORANI	%	64,0	Bouyocus Hidrometre Metodu
SİLT ORANI	%	22,0	

Photo:18/02/2026 Soil Anaylse Report result showing that the shift in soil pH from 8.41 toward the neutral threshold of 7.0 has successfully bypassed the negative effects of high calcium carbonate, as evidenced by the 98% survival rate and the successful 2024 fruit set

REFERENCES

- **Akin, E.B., Karabulut, I., & Topcu, A. (2008).** Some compositional properties of main Malatya apricot (Prunus armeniaca L.) varieties. *Food Chemistry*, 107(2), 939-948.
- **Asma, B.M. (2011).** *Apricot Culture (Kayısı Kültürü)*. Malatya: İnönü University Publications.
- **EPA (Environmental Protection Agency) (2023).** *Greenhouse Gas Emissions from a Typical Passenger Vehicle: Emission Factors and Calculation Methods*.
- **European Commission (2017).** Commission Implementing Regulation (EU) 2017/1117 entering a name in the Register of Protected designations of origin and protected geographical Indications (Malatya Kayısısı (PDO)). *Official Journal of the European Union*.
- **FAO (2020).** *The State of Food and Agriculture: Overcoming water challenges in agriculture*. Rome: Food and Agriculture Organization of the United Nations.
- **Güllü, H., Canakci, H., & Al-Zubaydi, A. (2024).** Field observations on the geotechnical aspects of the February 2023 Kahramanmaraş Earthquakes. *Journal of Earthquakes and Tsunamis*.
- **Moraes, M.T., et al. (2017).** The use of humic substances from Leonardite as a soil conditioner and its effect on plant growth. *Journal of Soil Science and Plant Nutrition*, 17(3), 611-625.
- **Nowak, D.J., et al. (2013).** Carbon storage and sequestration by urban trees in the United States. *Environmental Pollution*, 178, 229-236.
- **Toader, G., et al. (2019).** The importance of fruit trees in carbon footprint reduction and climate change mitigation. *Journal of Environmental Protection and Ecology*, 20(2), 701-709.
- **World Bank (2022).** *Water in Agriculture: Understanding the Challenges and Opportunities*. Washington, DC: World Bank Group.