

Traditional Production of Siratany in Ranomay and Conservation Issues in the Amoron'i Onilahy Protected Area, Southwest Region of Madagascar

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Abstract

This study aims to evaluate the traditional production of *siratany* in Ranomay and its implications for biodiversity conservation within the Amoron'i Onilahy Protected Area in southwestern Madagascar. Specifically, it describes the traditional production process and assesses its biological, physical, and socio-economic impacts. A mixed-methods case study approach was employed, integrating field observations, semi-structured interviews, household surveys, and a focus group discussion with 40 respondents comprising production workers, kettle owners, fuelwood sellers, and members of VOI TSIFA. Quantitative data were analyzed using descriptive statistics, while qualitative information was examined through thematic analysis. The results revealed that *siratany* production remains a family-based activity founded on indigenous knowledge transmitted across generations and consists of four major stages: preparation, brine filtration, combustion, and drying. Each production cycle consumes approximately 60 L of water and an average of 15 pieces of fuelwood per kettle, indicating substantial dependence on local natural resources. The activity provides an important source of household income and supports local markets, thereby contributing to rural livelihoods and the preservation of cultural heritage. However, increasing fuelwood demand and reliance on traditional wood-fired combustion may intensify pressure on dry forest ecosystems and pose environmental and health concerns if resource use is not sustainably managed. Community-based conservation initiatives led by VOI TSIFA, including reforestation and environmental awareness activities, demonstrate the potential for integrating traditional livelihoods with biodiversity conservation, although institutional and resource limitations remain. The study concludes that improving fuelwood management, promoting energy-efficient production technologies, strengthening community participation, and enhancing the market value of *siratany* are essential to ensuring the long-term sustainability of this traditional industry while supporting the conservation objectives of the Amoron'i Onilahy Protected Area.

Keywords: *Siratany*; Conservation; Onilahy; Ranomay; Madagascar.

Introduction

Biodiversity conservation has become a global priority as natural ecosystems continue to experience unprecedented degradation caused by climate change, land-use change, overexploitation of natural resources, and increasing anthropogenic pressures (Oldekop et al., 2016; Randevoson, 2009; Scoones, 2021). Protected areas constitute one of the principal strategies for safeguarding biodiversity because they conserve habitats, maintain ecosystem services, and preserve ecological processes essential for environmental sustainability. Nevertheless, the effectiveness of protected areas increasingly depends on their capacity to reconcile biodiversity conservation with the livelihood needs of communities living within and around them (UNDP, 2022). In many developing countries, particularly in rural regions where poverty remains widespread, local populations rely

heavily on natural resources for food, energy, construction materials, medicine, and income generation. Consequently, the long-term success of conservation initiatives is closely linked to sustainable natural resource management that simultaneously supports ecosystem integrity and local socio-economic development.

The relationship between biodiversity conservation and rural livelihoods is particularly complex in sub-Saharan Africa, where millions of households depend directly on forests, wetlands, rivers, and other natural ecosystems for their daily survival (IPCC, 2023). Community-based conservation has therefore emerged as a widely adopted approach that promotes local participation in natural resource governance while encouraging sustainable livelihood opportunities (Dasgupta, 2021; Eric et al., 2025). Although this participatory model has generated positive outcomes in several countries, its effectiveness depends largely on local governance systems, institutional capacity, community participation, and the availability of economically viable alternatives to unsustainable resource exploitation. Recent studies emphasize that conservation interventions are more successful when local communities receive tangible socio-economic benefits from protecting biodiversity, thereby reducing their dependence on environmentally destructive activities (Andrianambinina et al., 2025; Ralimanana et al., 2022). Understanding traditional resource-use systems has consequently become an essential component of contemporary conservation science because indigenous production practices frequently represent both opportunities and challenges for sustainable environmental management.

Madagascar occupies a unique position in global biodiversity conservation because it is recognized as one of the world's most important biodiversity hotspots (IPBES, 2022; UNEP, 2021). Owing to its long geographical isolation, the island harbors exceptionally high levels of endemism, with more than 80% of its terrestrial plant and animal species occurring nowhere else on Earth. This extraordinary biological richness has attracted international scientific attention and motivated significant conservation investments over the past several decades (Birthal & Hazrana, 2019; FAO, 2022). Despite these efforts, Madagascar continues to experience rapid environmental degradation driven by deforestation, agricultural expansion, charcoal production, mining, illegal logging, uncontrolled fires, and the widespread dependence of rural populations on natural resources (Gardner et al., 2018; Ralimanana et al., 2022; Andrianambinina et al., 2025). Recent analyses further indicate that forest loss remains a persistent concern both inside and outside protected areas, highlighting the continuing challenge of reconciling conservation objectives with the socio-economic realities of rural communities.

Recognizing these challenges, Madagascar has progressively expanded its protected area network while strengthening community participation through decentralized natural resource management (Andriamihaja et al., 2019; Andriamparany et al., 2021). Community-based organizations known as Vondron'Olona Ifotony (VOI) have become key partners in implementing conservation programs by promoting local stewardship of forests, wetlands, and other ecosystems. These organizations seek to improve biodiversity protection while supporting sustainable economic activities that can enhance household incomes (MPAOPA, 2019; IUCN, 2021). However, previous studies have demonstrated that community management alone does not necessarily guarantee reductions in environmental degradation if resource use remains poorly regulated or if alternative livelihood opportunities remain insufficient (Rasolofoson et al., 2015). Consequently, evaluating traditional economic activities practiced within protected landscapes has become increasingly important for understanding how conservation objectives can be better integrated with rural development strategies.

One of the most ecologically significant conservation landscapes in southwestern Madagascar is the Amoron'i Onilahy Protected Area, situated within the Southwest Region. The protected area encompasses a remarkable diversity of ecosystems, including spiny forests, dry deciduous woodlands, wetlands, marshes, lakes, gallery forests, and riparian

habitats associated with the Onilahy River. These ecosystems provide habitat for numerous endemic species characteristic of Madagascar's dry forests while simultaneously delivering essential ecosystem services to surrounding communities. Timber resources, freshwater supplies, grazing lands, fisheries, medicinal plants, and non-timber forest products constitute important components of local livelihoods. The ecological importance of the protected area has therefore been recognized through collaborative conservation initiatives involving government agencies, conservation organizations, and community-based institutions. Nevertheless, the area continues to experience significant anthropogenic pressures, including fuelwood extraction, illegal logging, charcoal production, agricultural expansion, uncontrolled burning, and unsustainable exploitation of natural resources (WWF Madagascar, 2025a).

Among the communities located within the protected area, Ranomay represents a particularly distinctive landscape because of its exceptional geological and hydrological characteristics (DMP, 2019). The area contains saline soils, hot springs, wetlands, Lake Ranomay, and the Onilahy River, creating environmental conditions that have supported the development of a unique traditional rock salt industry locally known as *siratany*. Unlike marine salt produced through direct evaporation of seawater, *siratany* is obtained by extracting salts from naturally saline soils through an indigenous production process involving soil collection, brine filtration, evaporation, and manual drying. This traditional knowledge has been transmitted across generations and remains an important component of local cultural heritage while simultaneously providing supplementary income for many households. In addition to its economic value, *siratany* has become closely associated with the cultural identity of Ranomay and represents one of the few artisanal mineral production systems still actively practiced in southwestern Madagascar.

The production of *siratany* illustrates the intimate relationship between indigenous knowledge and the sustainable utilization of locally available natural resources. Nevertheless, maintaining this traditional production system requires substantial quantities of fuelwood, freshwater, and saline soils, thereby creating potential environmental pressures within a protected landscape dedicated to biodiversity conservation. The dependence of *siratany* production on natural resources raises important questions concerning its long-term sustainability, particularly as rural populations continue to rely on artisanal activities for income generation under conditions of persistent poverty and limited economic diversification. Understanding these interactions is therefore essential for identifying production practices that support local livelihoods while minimizing ecological impact.



Figure 1. Onilahy River, Ranomay Lake, and thermal spring in Ranomay (Author's field note)

Traditional salt production has long been practiced in many parts of the world as a livelihood activity closely linked to local environmental conditions and indigenous knowledge. Unlike industrial salt production, artisanal methods generally depend on locally available natural resources and inherited production techniques that have evolved over generations. These traditional systems often contribute significantly to rural economies by creating employment opportunities, generating household income, and preserving cultural

heritage. At the same time, they frequently rely on biomass energy and freshwater resources, which may exert considerable pressure on surrounding ecosystems when production intensifies or when resource extraction is not effectively regulated. Consequently, artisanal salt production has increasingly attracted scientific attention because of its implications for sustainable resource management, rural development, and biodiversity conservation.

Recent studies have highlighted the dual nature of traditional salt production systems. In Senegal, for example, artisanal solar salt production has been shown to provide substantial socio-economic benefits to local communities while simultaneously creating environmental challenges associated with resource exploitation and ecosystem disturbance (Fall et al., 2021). Similar observations have been reported in other developing countries, where traditional mineral production supports household livelihoods but remains constrained by low production efficiency, high biomass consumption, and limited technological innovation. These studies demonstrate that improving traditional production systems requires not only technological interventions but also a comprehensive understanding of their ecological, economic, and social dimensions. Such integrated assessments are particularly important in protected landscapes where conservation objectives must be balanced with the livelihood needs of local communities.

In Madagascar, *siratany* represents one of the country's least documented traditional mineral resources despite its long history of local use. Produced from naturally saline soils rather than seawater, *siratany* is manufactured through an indigenous process involving the collection of saline earth, filtration to obtain brine, prolonged boiling using fuelwood, and subsequent drying before commercialization. The product is widely appreciated in southwestern Madagascar as a traditional cooking salt and is considered by local communities to possess distinctive characteristics associated with its natural origin (UNDP, 2022; Emynorane et al., 2025). Although local knowledge suggests that *siratany* contains valuable mineral elements, including potassium and other trace elements, its physicochemical composition has not yet been comprehensively investigated using modern analytical methods. Consequently, the nutritional and commercial value attributed to *siratany* remains largely based on traditional knowledge and requires further scientific validation.

Beyond its cultural importance, *siratany* production represents a significant livelihood strategy for households in Ranomay. The activity involves producers, laborers, fuelwood suppliers, traders, transporters, and local community organizations, thereby contributing directly to the rural economy. Income generated from *siratany* supports household expenditures related to food, education, healthcare, and other essential needs, particularly during periods when the semi-arid climate of southwestern Madagascar constrains agricultural production. In regions where opportunities for economic diversification remain limited, artisanal industries such as *siratany* production constitute an important component of household resilience and poverty reduction. Nevertheless, the sustainability of these livelihood systems depends on maintaining the natural resource base upon which they rely.

Despite its socio-economic importance, relatively little scientific research has examined the environmental implications of *siratany* production within the context of biodiversity conservation. Previous studies have primarily described the traditional production process or documented the geological occurrence of saline deposits in the Onilahy Valley (Rasolondrainy, 2009; Rasoarimanana, 2008). Likewise, management plans prepared for the Amoron'i Onilahy Protected Area and the Ranomay community have identified *siratany* as a locally important economic activity but have provided only limited evaluation of its ecological consequences. More recently, conservation organizations have promoted Ranomay rock salt as a distinctive local product with considerable economic potential (WWF Madagascar, 2025b). However, these publications have largely focused on promoting community development rather than evaluating the sustainability of resource extraction practices or quantifying their impacts on biodiversity and ecosystem integrity.

Furthermore, most existing studies addressing community-based conservation in Madagascar have concentrated on forest management, deforestation, agricultural expansion, or governance issues, while comparatively little attention has been devoted to artisanal mineral production systems operating within protected areas (Gardner et al., 2018; Rasolofoson et al., 2015). Consequently, significant knowledge gaps remain regarding the quantity of natural resources consumed during *siratany* production, the environmental pressures associated with fuelwood and water use, and the extent to which this traditional activity can be integrated into sustainable conservation strategies. Addressing these gaps is particularly important in the Amoron'i Onilahy Protected Area because its dry forests and wetlands are characterized by high ecological sensitivity and exceptional levels of biodiversity. As pressures on natural resources continue to increase under conditions of population growth, climate variability, and rural poverty, evidence-based management strategies are needed to ensure that traditional livelihood activities remain compatible with long-term conservation objectives (World Bank, 2022).

The present study addresses these knowledge gaps by providing a comprehensive assessment of the traditional production of *siratany* in Ranomay within the broader framework of biodiversity conservation and community-based natural resource management. Unlike previous investigations, this research simultaneously examines the production process, estimates the consumption of fuelwood and water resources, evaluates the biological, physical, and socio-economic impacts of the activity, and considers its implications for sustainable management within the Amoron'i Onilahy Protected Area. By combining field observations, socio-economic surveys, focus group discussions, and descriptive analyses, the study offers an integrated perspective on the complex interactions between indigenous knowledge, natural resource utilization, household livelihoods, and ecosystem conservation.

The findings are expected to make several important contributions. Scientifically, the study provides updated empirical evidence on a traditional mineral production system that has received little attention in international literature despite its ecological and socio-economic significance. The research also contributes to broader discussions concerning the sustainability of artisanal production systems operating within biodiversity hotspots, where conservation objectives frequently intersect with local development priorities. From a practical perspective, the results provide valuable information for community organizations such as VOI TSIFA, conservation practitioners, policymakers, and development partners seeking to strengthen participatory natural resource management while improving local livelihoods (Convention on Biological Diversity, 2022; Emynorane et al., 2026). The study further supports ongoing efforts to promote sustainable production techniques, improve energy efficiency, reduce pressure on woody vegetation, and enhance the economic value of *siratany* through better resource governance and community participation.

Ultimately, understanding the interactions between traditional *siratany* production and biodiversity conservation is essential for developing management strategies that recognize both the ecological importance of the Amoron'i Onilahy Protected Area and the socio-economic realities of the communities that depend upon its natural resources. This study therefore aims to evaluate the conditions necessary for the sustainable utilization of *siratany* as an important local natural resource while remaining consistent with the conservation objectives of the protected area. Specifically, it seeks to (i) describe the traditional production process of *siratany* in Ranomay, including resource extraction, processing techniques, and marketing practices, and (ii) assess the biological, physical, and socio-economic impacts associated with this traditional activity. By providing a comprehensive assessment of this unique artisanal production system, the study contributes to the growing body of knowledge supporting the integration of indigenous livelihoods, sustainable resource management, and biodiversity conservation in Madagascar's protected landscapes.

Methodology

This study used a descriptive case study design using a mixed-methods approach to examine the traditional production of *siratany* and its environmental and socio-economic implications within the Amoron'i Onilahy Protected Area, southwestern Madagascar. The research was conducted in Ranomay, Rural Commune of Tameantsoa, Betioky-Sud District, Southwest Region, where *siratany* production remains an important traditional livelihood. Primary data were collected during fieldwork conducted in 2025, while secondary information was obtained from scientific publications, management plans, institutional reports, and policy documents related to biodiversity conservation, community-based natural resource management, and traditional salt production in Madagascar.

Field data were collected through direct observation, semi-structured interviews, socio-economic surveys, and a focus group discussion. Direct observations documented the successive stages of *siratany* production, including saline soil collection, brine filtration, combustion, drying, and marketing, as well as the use of wood, water, and production equipment. Socio-economic surveys were conducted with 40 purposively selected respondents comprising 20 production workers, 10 kettle owners, and 10 fuelwood sellers, all of whom possessed direct knowledge of the production process. A focus group discussion with members of VOI TSIFA, the local community organization responsible for co-managing the protected area, provided additional information on natural resource governance, conservation initiatives, and community perceptions regarding the environmental and economic importance of *siratany*. Geographic coordinates of the study area and production sites were recorded using a handheld GPS and processed in QGIS to produce the location map.

Quantitative data were entered into and analyzed using Microsoft Excel. Descriptive statistics, including frequencies, percentages, averages, and annual estimates, were used to characterize the production system and estimate wood consumption, water use, production volume, and gross production value. Annual estimates were calculated based on the average number of operating kettles, daily production, seasonal working schedules, and resource consumption reported by producers. These calculations were intended to describe the scale of resource use associated with traditional *siratany* production within the study area.

Qualitative data obtained from observations, interviews, and the focus group were analyzed using thematic content analysis. Information was organized according to the study objectives, including the traditional production process, natural resource utilization, environmental impacts, socio-economic benefits, and community conservation practices. The integration of qualitative and quantitative evidence enabled a comprehensive assessment of *siratany* production and its relationship with biodiversity conservation and rural livelihoods in the Amoron'i Onilahy Protected Area.

Results and Discussion

Results

The results are presented according to the two objectives of the study. The first describes the traditional production process of *siratany* in Ranomay. In contrast, the second examines its biological, physical, and socio-economic impacts within the conservation context of the Amoron'i Onilahy Protected Area.

Traditional production process of siratany in Ranomay

The study involved 40 respondents comprising 20 production workers, 10 kettle owners, and 10 fuelwood sellers. Additional information on community-based natural resource management and conservation practices was obtained through a focus group discussion with members of VOI TSIFA, the local community organization responsible for co-managing the protected area.

The findings indicate that *siratany* production is based on indigenous knowledge transmitted across generations and remains predominantly a family-based activity. Production is concentrated in traditional salt-bearing areas that are recognized and managed according to customary land-use practices. On average, each household involves three to six family members in production and owns between one and three kettles. The traditional production process consists of four successive stages: preparation, brine filtration, combustion, and drying. Under normal conditions, one complete production cycle is completed within a single day for each kettle.

The preparation stage begins with the collection of saline surface soil from designated production sites using a traditional tool locally known as a *fikaoke*. The harvested soil is transported to the production area and placed in a large woven filter (*tsihy*). A filtering layer consisting of one to two baskets of coarse sand (approximately 15 kg per basket) is first arranged to reduce suspended particles during filtration. Approximately three baskets (about 45 kg) of saline soil are then added, and in some cases, producers incorporate wood ash equivalent to about half the quantity of soil. Although producers could not clearly explain the function of the ash, they consistently considered it an inherited practice that improves the quality of the brine. Finally, approximately 60 L of water is poured over the mixture to dissolve the soluble salts and produce the saline solution.

The second stage consists of filtering the saline solution to obtain the brine. A hollow reed stem locally known as *kidresy* is inserted into the filter to facilitate the controlled discharge of the salt solution. On average, 60 L of water produces approximately 20–25 L of brine. The filtration process generally requires between two and four hours, depending on the condition of the filter, the quantity of sand used, and the efficiency of water drainage.

The brine is subsequently transferred to locally fabricated metal kettles measuring approximately 0.80–1.00 m on each side and heated over wood-fired stoves until the water completely evaporates. Fuelwood constitutes the sole energy source used during production. Producers preferentially utilize hardwood species, including *Grewia grevei* (*kotipoke*), *Dichrostachys tenuifolia* (*avoha*), *Cedrelopsis grevei* (*katrafay*), and *Tamarindus indica* (*tamarind*), although softer species such as *Euphorbia stenoclada* (*famata*) and *Gyrocarpus americanus* (*kapaipoty*) are also used when necessary. Survey results indicate that each kettle consumes an average of 15 pieces of fuelwood, approximately 1 m in length, during a single production cycle. A cartload of fuelwood costs an average of 15,000 Ariary.

Following evaporation, the crystallized salt is sun-dried for two to five hours before being manually ground to remove coarse impurities and dark residues formed during heating. The finished product is either marketed immediately or stored temporarily until scheduled market days. Four principal marketing channels were identified (Figure X). Nearly half of the producers (49%) sell directly in Tongobory, followed by 22% in Tameantsoa. Approximately 14% store their products before sale, whereas 15% sell directly to intermediaries operating at the production site.



Figure 2. Traditional Siratany Production Process in Ranomay (Author's field note, 2026)

Impacts of siratany production on the biological, physical, and human environment

Pressure on woody resources and estimation of biomass used

The results show that siratany production puts significant pressure on Ranomay's timber resources. Wood is the primary energy source used for burning the brine.



Figure 3. Brine Evaporation in Ranomay (Author's field note, 2026)

On average, a kettle uses about fifteen pieces of wood, each approximately one meter long, per day. With 37 kettles recorded in the production area, the average daily consumption is estimated at:

$$15 \text{ pieces} \times 37 \text{ kettles} = 555 \text{ pieces of wood per day}$$

During the faosa season (April to October), producers work approximately five days out of seven. During the asara season (November to March), they work approximately three days out of seven due to the rains and flooding of the Onilahy River. The estimated annual consumption is shown in Table 1 below.

Table 1. Annual estimate of woody biomass consumption

Season	Estimated number of working days	Daily consumption	Estimated annual consumption
Faosa	150 days	555 pieces	83,250 pieces
Asara	64 days	555 pieces	35,520 pieces
Total annual	214 days		118,770 pieces

These results show that the *siratany* sector mobilizes a significant amount of woody biomass each year. Even though producers report using mainly dead wood, field observations show that such a quantity is hardly available solely in the form of naturally fallen dry wood. The interviews also revealed that 80% of respondents felt that wood was becoming increasingly difficult to find around Ranomay. Approximately 15% felt there had been no significant change yet, while 5% had no clear opinion on the matter.

Producers typically collect timber within a radius of approximately 15 km around the village of Ranomay. This distance demonstrates that the pressure on timber resources is no longer limited to the immediate vicinity of the production site. The environmental impact primarily concerns the biological environment, particularly thorny thickets and woody species used as fuel. The preferential selection of hardwoods can gradually reduce the availability of the most sought-after species and alter the structure of the local vegetation.

These results therefore confirm hypothesis 1 that *siratany* production exerts significant pressure on local natural resources through the intensive use of wood as an energy source.

Pressure on water resources

The production of *siratany* also requires a significant amount of water. A kettle uses approximately 60 liters of water per day for the preparation and filtration of the brine.

For the 37 kettles identified in the study area, the estimated daily consumption is: 60 liters × 37 kettles = 2,220 liters of water per day. The estimated annual consumption is shown in Table 2 below.

Table 2. Estimated annual water consumption

Season	Estimated number of working days	Daily consumption	Estimated annual consumption
Faosa	150 days	2,220 liters	333,000 liters
Asara	64 days	2,220 liters	142,080 liters
Total annual	214 days		475,080 liters

The results show that the sector uses approximately 475 m³ of water per year. This water comes mainly from the Onilahy River, which is also the main source of water used for household domestic needs. Even though this quantity remains relatively small on the scale of the river, it represents significant local pressure when combined with other water uses in the village. The sector's dependence on local water resources demonstrates that the activity remains closely linked to the environmental conditions of Ranomay.

Air pollution and physical impacts

The combustion of wood used to heat the brine produces a significant amount of smoke at production sites. This smoke results from the incomplete combustion of the wood and potentially contains fine particles, carbon monoxide, and other compounds from the burned organic matter.

Observations show that producers often work in the immediate vicinity of combustion sites and remain regularly exposed to smoke during long cooking periods.

The impact primarily concerns the physical environment and working conditions of producers. Repeated exposure to smoke can cause eye irritation, breathing difficulties, and physical discomfort, particularly among women heavily involved in cooking operations.

These results therefore show that the production of *siratany* also has impacts on the physical environment through air pollution linked to the use of wood energy.

Socio-economic importance of the siratany sector

Despite the observed environmental pressures, *siratany* production plays a major economic role in Ranomay. The sector directly involves kettle owners, workers, wood sellers, sub-collectors, traders, and the VOI TSIFA.

The results show a strong involvement of women in this activity. Women represent approximately 46% of the actors involved, compared to 30% for men and 24% for young people.

Women primarily handle tasks related to preparing, cooking, and marketing the product. Men are more involved in transporting wood and water. Young people contribute to support activities and family tasks related to production.

This organization demonstrates that *siratany* is a family activity deeply integrated into local subsistence strategies. In most cases, the tasks are carried out within the household, thus limiting external expenses and retaining a large portion of the income within the family.

The results also show that a kettle produces an average of 35 kapoaka of salt per day. With 37 kettles identified in the study area, the total daily production is estimated at:

$$35 \text{ kapoaka} \times 37 \text{ kettles} = 1,295 \text{ kapoaka per day}$$

Table 3. Annual estimate of siratany production

Season	Estimated daily production	Estimated number of working days	Annual production
Faosa	1,295 kapoaka	150 days	194,250 kapoaka
Asara	1,295 kapoaka	64 days	82,880 kapoaka
Total annual		214 days	277,130 kapoaka

The price of *siratany* varies according to the seasons. During the asara, the average price reaches approximately 400 Ariary per kapoaka, while it drops to approximately 200 Ariary during the faosa.

Table 4. Estimated annual gross value of production

Season	Estimated production	Average price	Estimated gross value
Faosa	82,880 kapoaka	400 Ar	33,152,000 Ar
Asara	194,250 kapoaka	200 Ar	38,850,000 Ar
Total annual	277,130 kapoaka		72,002,000 Ar

The results show that the sector generates an estimated annual gross value of over 72 million Ariary. This activity therefore represents a significant source of income for local households. The income from *siratany* is primarily used for basic household needs. Approximately 60% of the income is used for food, 23% for health, and 17% for children's education.

These results show that *siratany* plays an important role in the economic resilience of rural households in Ranomay. The strong involvement of women also demonstrates that this activity contributes to family economic stability and to meeting daily needs. The members of VOI TSIFA unanimously consider the *siratany* sector an important economic alternative for local populations and one that can help mitigate certain forms of pressure on biodiversity. However, they also emphasize that this activity needs to be better regulated to reduce its impact on the surrounding forest. According to VOI TSIFA, monitoring of the territory and patrols carried out in the Amoron'i Onilahy Protected Area allow them to observe the effects of timber harvesting around Ranomay directly.

The results also show that the TSIFA VOI participates in reforestation activities supported by WWF and the MIONJO project. A system of financial contributions also exists within the sector. Producers sometimes pay between 5,000 and 10,000 Ariary per market day in Tongobory to support certain VOI activities. However, this system remains unstable, as not all producers pay these contributions regularly.



Figure 4. Andraketa Nursery Center managed by VOI TSIFA (Author's field note, 2026)

This situation highlights the existing trade-off between conservation and local livelihoods. On the one hand, the *siratany* sector exerts real pressure on natural resources, particularly timber resources. On the other hand, it represents a vital economic activity for many rural households living in poverty and with limited economic diversification.

Thus, the results show that the relationship between poverty and conservation remains complex in the study area. *Siratany* is both a source of environmental pressure and a local strategy for economic resilience. These results therefore confirm the hypothesis that *siratany* represents a valuable local resource that can contribute to the livelihoods of local communities, provided that its production is better managed within a framework of sustainable management and conservation.

Discussion

The findings demonstrate that traditional *siratany* production in Ranomay represents a complex socio-ecological system in which local livelihoods are closely linked to the use of natural resources within the Amoron'i Onilahy Protected Area. The dependence of production on fuelwood and water illustrates the challenges of maintaining traditional artisanal activities in a conservation landscape where ecological sustainability and community welfare must be simultaneously achieved. Although producers reported that deadwood is generally preferred for fuel, the estimated annual consumption of nearly 118,770 pieces of wood indicates a substantial demand for woody biomass. In dry forest ecosystems such as those of southwestern Madagascar, where vegetation is already affected by agricultural expansion, charcoal production, illegal logging, and recurrent fires, continued dependence on fuelwood may contribute to increasing pressure on forest resources if harvesting is not effectively managed (WWF, 2025; Andrianambinina et al., 2025). The perception among most producers that fuelwood is becoming more difficult to obtain, together with the increasing distance travelled for wood collection, further suggests that accessible resources are gradually declining. Similar patterns have been reported in other fuelwood-dependent rural production systems, where resource scarcity progressively increases harvesting distances and production costs (Scales, 2018).

The study also highlights the environmental implications associated with traditional production techniques. The use of open wood-fired combustion to evaporate brine generates considerable smoke, reflecting the relatively low energy efficiency of the current production system. Similar observations have been reported for artisanal salt production in Senegal, where traditional processing methods require large quantities of biomass and produce significant emissions due to incomplete combustion (Fall et al., 2021; Bhagyanathan & Dhayanithy, 2023). Beyond environmental concerns, prolonged exposure to smoke may affect the health of producers, particularly women, who constitute an important proportion of the workforce involved in boiling and processing activities. Exposure to particulate matter

and other pollutants released during biomass combustion has been associated with respiratory and ocular health problems in rural communities that depend on traditional cooking technologies (World Health Organization, 2025). These findings suggest that improving stove efficiency or adopting more energy-efficient processing technologies could reduce both environmental impacts and occupational health risks while maintaining the traditional characteristics of *siratany* production.

Despite these environmental concerns, *siratany* remains an important livelihood strategy for households in Ranomay. Income generated from production contributes directly to meeting essential household needs, including food, education, and healthcare, thereby strengthening the economic resilience of rural families in a region where livelihood opportunities are limited. This finding supports previous studies showing that communities living around protected areas in Madagascar remain highly dependent on natural resources for income and subsistence (Gardner et al., 2018). Consequently, restricting traditional activities without providing viable economic alternatives may undermine local support for conservation initiatives. Rather than viewing *siratany* production solely as a source of environmental pressure, it should also be recognized as an important component of rural livelihood systems whose sustainability depends on improving resource-use efficiency rather than eliminating the activity itself.

The results further emphasize the importance of community-based conservation in balancing resource use and biodiversity protection. VOI TSIFA's involvement in awareness campaigns, community patrols, and reforestation activities demonstrates the potential of participatory governance to promote sustainable natural resource management within the protected area (World Resources Institute, 2023). However, irregular financial contributions from producers and inconsistent participation in conservation activities indicate that community governance still faces important institutional and economic challenges. Similar limitations have been documented in community-based conservation initiatives elsewhere in Madagascar, where immediate household needs often constrain compliance with local management rules despite positive attitudes toward conservation (Rasolofoson et al., 2015). Strengthening collaboration among local communities, conservation organizations, and government agencies will therefore be essential for improving the sustainability of *siratany* production. Measures such as promoting fuel-efficient technologies, encouraging reforestation in wood collection areas, improving production efficiency, and strengthening community participation could reduce environmental pressures while preserving the economic and cultural importance of this traditional industry. These integrated approaches would contribute to achieving the dual objectives of biodiversity conservation and sustainable rural development within the Amoron'i Onilahy Protected Area.

Conclusion

This study demonstrated that the traditional production of *siratany* in Ranomay is an important indigenous livelihood that contributes to household income and preserves local cultural heritage while depending heavily on natural resources within the Amoron'i Onilahy Protected Area. Although the activity provides significant socio-economic benefits, its reliance on fuelwood and water presents potential environmental challenges that may increase pressure on the surrounding dry forest ecosystem if resource use remains unmanaged. The findings underscore the need to strengthen community-based conservation by promoting sustainable fuelwood management, expanding reforestation initiatives, improving energy-efficient production technologies, and enhancing collaboration among local communities, VOI TSIFA, conservation organizations, and government agencies to ensure that traditional livelihoods remain compatible with biodiversity conservation objectives. At the same time, the cultural and economic value of *siratany* should be recognized through initiatives that improve product quality, market access, and value addition. Future research should investigate the physicochemical and nutritional properties

of *siratany*, evaluate alternative low-carbon production technologies, and assess the long-term ecological impacts of resource extraction to support evidence-based management and the sustainable development of this unique traditional industry within Madagascar's protected areas.

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