# DESCRIPTION OF INTERVENTIONS

## 3.1. Introduction

The current decision analysis is designed as an extension of the empirical study conducted in 2024, which focused on labour use efficiency and intra-household labour allocation within smallholder agroforestry systems. This foundational study provides the necessary empirical data and analytical framework for developing targeted interventions aimed at enhancing productivity and equity. Building on the previous findings, this decision analysis grounds proposed interventions in real-world conditions and region-specific challenges.

The previous study specifically examined the dynamics of labour within smallholder agroforestry farmers located in the Tubah Subdivision, providing a detailed understanding of existing practices and inefficiencies. This geographical focus allows for a nuanced and context-specific analysis, ensuring that the interventions are tailored to the unique socio-economic and environmental conditions of the area. The insights gained from the study serve as a baseline against which the potential impacts of the proposed interventions can be measured, thereby facilitating a more accurate and reliable assessment of their effectiveness.

This analysis aims to promote equitable labour restructuring and integrate appropriate technologies within agroforestry systems. This involves identifying strategies that can address existing gender imbalances in labour allocation, reduce the physical intensity of agricultural tasks, and improve overall system productivity. By focusing on both social and technological aspects, the decision analysis seeks to create a more sustainable and inclusive agroforestry sector that benefits all members of the community. The emphasis on cooperative-based technological integration ensures that the proposed solutions are not only effective but also accessible and adaptable to the needs of smallholder farmers.

## 3.2. Baseline

The baseline scenario reflects agroforestry labour practices in the Tubah Subdivision characterized by high physical intensity, gendered labour division, and minimal mechanization. It serves as a benchmark for assessing the effectiveness of interventions aimed at enhancing labour efficiency and promoting sustainable practices.

Labour is mainly sourced from family members, particularly women and children, with seasonal hired labour used during peak periods. This household-based labour model shapes productivity and reflects fluctuating demands across crop production stages. Understanding this dynamic is essential for designing interventions that ease the burden on vulnerable household members and stabilize labour availability.

Manual tools such as hoes and cutlasses dominate due to limited access to mechanized equipment. This dependence on manual labour reduces efficiency and increases physical strain, impacting farmer health and productivity. Addressing this constraint requires better access to credit, affordable technology, and farmer training.

Farm sizes range from 0.25 to 8 hectares, with intercropping of food crops (maize, cassava, beans) and perennials (cocoa, oil palm, eucalyptus). Labour-intensive operations such as land clearing and ridge formation are mostly performed by men, while women dominate weeding, harvesting, and domestic work, contributing an average of 7.87 hours per day to household tasks.

## 3.3. Decision option 1: Cooperative-Driven Mechanization

This intervention proposes a cooperative model where smallholder farmers jointly invest in and manage agricultural machinery. By pooling resources, members reduce the burden of high initial investment costs, enabling access to capital-intensive inputs like tractors and harvesters’ tools that are otherwise inaccessible to individual farmers (Ngu, Tumenta, & Amungwa, 2020; Tumenta, Ngum, & Tabi, 2021).

The conceptual model highlights key cost components such as machine purchase contributions, membership fees, fuel, and maintenance. These recurring costs are offset by measurable benefits, including reduced physical labour, improved efficiency, seasonal labour savings, and additional farm income. Mechanized operations can reduce labour inputs by up to 50 %, enabling timely execution of tasks like land preparation and harvesting, which are often bottlenecks in traditional systems (Ngum et al., 2024).

This intervention is not without risks; machine downtime, fuel access issues, and skill deficits are potential constraints. However, cooperative coordination enables shared training sessions to address skill gaps, and onsite repairs to reduce delays. The approach also introduces structured planning and execution phases, with training hours contributing to increased operational efficiency. Net Present Value (NPV) calculations based on the conceptual flow further support the long-term viability of this intervention.

Germany’s Maschinenringe model remains a relevant benchmark. According to Kühl (2012), Maschinenringe cooperatives have demonstrated the capacity to streamline machinery usage among smallholders, enhance economic returns, and deliver technical services efficiently. These cooperatives not only coordinate equipment use but also offer advisory and training programs, reflecting a comprehensive institutional model adaptable to Tubah’s context.

Further, insights from the German-Brazilian exchange on mechanization in smallholder agriculture affirm the value of cooperative-led machinery deployment. As reported by IAK Agrar Consulting GmbH (2025), German models such as Maschinenringe have been successfully adapted in Brazil to support mechanization through farmer organizations. These initiatives emphasize joint ownership, training, and efficient scheduling elements that parallel the conceptual model adopted in this intervention. Brazilian smallholders, like those in Tubah, faced challenges of fragmented land and limited financial capital. The exchange highlighted how tailored cooperative structures can bridge these gaps, ensure machinery availability while promoting skill acquisition and maintenance support.

In Tubah, fragmented plots and financial constraints make standalone mechanization impractical. Cooperative-driven mechanization provides a feasible alternative by optimizing machinery use and embedding services such as training, maintenance, and planning support. This model transforms the cooperative into a service hub, strengthening institutional capacity, enhancing productivity, and building resilience among agroforestry smallholders.

## 3.4. Decision option 2: Cooperative with Gender-Balanced Labour Allocation

This intervention aims to address the pervasive gender disparities in labour distribution within the agricultural sector, specifically in Tubah, where women face unique challenges due to cultural and structural barriers. Empirical evidence highlights that women often undertake extensive domestic responsibilities alongside agricultural labour tasks such as soil tilling, planting, weeding, and harvesting without receiving equitable recognition or support, which impacts their productivity adversely (Zhang et al., 2023; Blau & Kahn, 2017).

The cooperative model proposed in this intervention serves as a framework for promoting equitable task sharing and enhancing women’s active participation in high-value agricultural tasks. Research indicates that cooperative systems can effectively mediate resource sharing, allowing for a more balanced allocation of labour (Garcia, 2021; Blau & Kahn, 2017). By structuring labour pooling and scheduling that respects domestic obligations, cooperatives can alleviate the burdens women face, facilitating their engagement in more productive and profitable activities Zhu & Li, 2021) Blau & Kahn, 2017). For instance, the collective approach can ensure that women have access to training and skill development relevant to agricultural enhancement, thus improving not only their economic standing but also fostering community empowerment (Huang & Azman, 2023; Zhu & Li, 2021).

The implementation of a gender-sensitive cooperative model presents a range of benefits that are critically relevant to enhancing both economic outcomes and social equity. Specifically, this framework promotes efficient labour distribution, which is essential to maximizing productivity within agricultural settings (FAO, 2018). The model fosters increased employment continuity for women, thereby contributing to improved household incomes. Furthermore, it has been linked to enhanced health and nutritional outcomes, as families benefit from a more stable economic base (UN Women, 2019).

In addition to economic benefits, the cooperative approach facilitates women's empowerment, fosters community development, and contributes to enhanced household harmony. These outcomes are closely aligned with multiple United Nations Sustainable Development Goals (SDGs), notably Goals 1 (No Poverty), 5 (Gender Equality), 8 (Decent Work and Economic Growth), and 10 (Reduced Inequalities) (UN, 2020). By structuring participation within cooperatives, women are afforded the opportunity to bridge seasonal labour gaps, which allows them to engage more fully in decision-making processes and avail themselves of training programs that bolster their skill development and productivity (World Bank, 2020).

Despite these gains, risks such as cultural resistance, poor coordination, free-riding, and payment inconsistencies remain. These challenges can disrupt equitable participation and impact long-term program success. Effective leadership, transparency, and conflict resolution mechanisms within cooperatives are essential to mitigating these risks.

By organizing labour resources through a gender-sensitive cooperative model, this intervention not only promotes equity but also strengthens community resilience, economic inclusion, and the sustainability of agroforestry systems in Tubah.