# CHAPTER THREE

# Materials and Methods

## Introduction

The aim of this chapter is to assess the effectiveness of selected labour optimization strategies namely labour cooperatives, mechanization, and gender-based redistribution in improving labour use efficiency among smallholder agroforestry farmers. To achieve this, an existing smallholder agroforestry household is selected as a reference case, based on baseline survey data. This household serves as the modelling unit for simulating the operational, economic, and social implications of the proposed strategies.

The sections that follow provide a detailed overview of the study area, outlining its biophysical, socio-economic, and institutional characteristics relevant to labour dynamics and agroforestry practices. This is followed by an in-depth description of the selected case household, including farm size, labour structure, crop composition, and cooperative affiliation, which together define the empirical foundation for modelling.

A comprehensive explanation of each labour optimization scenario is presented, capturing both conceptual underpinnings and practical implementation considerations. The chapter then outlines the methodological framework used to model and simulate the agroforestry labour system both conceptually and mathematically. This includes the specification of decision-relevant variables, development of cost-benefit structures, risk analysis, and the use of Net Present Value (NPV) as a central indicator for comparative evaluation. Lastly, the decision-support tools and simulation environment applied in the analysis are described.

## Study Area

The study was conducted in Tubah Sub-Division, located in Mezam Division, within the North West Region of Cameroon. Tubah is situated approximately 15 km from Bamenda, the regional capital, and lies between latitude 4°50'N–5°20'N and longitude 10°35'E–11°59'E, with elevations ranging between 950 m and 1,500 m above sea level.

### Administrative and Physical Description

Tubah is composed of six villages, of which four Bambili, Bambui, Kedjom-Keku (Big Babanki), and Kedjom-Ketinguh (Small Babanki) were selected for this study. These villages were purposively sampled to capture agroecological variation and diversity in farming systems. The area covers a landmass of approximately 388.75 km², with a growing population estimated at over 73,000 as of 2013, resulting in a population density of about 145 persons per km².

The physical landscape includes flat woody lowlands, grazing fields, agricultural lands, forests, and riparian ecosystems fed by multiple springs and streams, especially prominent in the northern zone. Notably, the Kedjom-Keku forest area holds significance for its biodiversity and role in traditional agroforestry systems.

### Climate and Vegetation

Tubah lies within the Western Highlands agroecological zone and experiences a tropical highland climate, with bimodal rainfall patterns and annual precipitation between 1,800-2,200 mm. Rainy seasons extend from March to October, and average temperatures fluctuate between 18°C and 22°C. The vegetation is predominantly savannah interspersed with patches of forest and cultivated trees such as eucalyptus, raffia palm, cola nut, and fruit-bearing species.

### Agricultural Systems and Land Use

Agriculture in Tubah is primarily smallholder-based and involves the integration of arable crops with perennial trees, forming what is locally recognized as agroforestry systems. Common arable crops include maize, beans, cassava, and potatoes, while tree species commonly intercropped or scattered on farms include Leucaena, Tephrosia, Calliandra, avocado, mango, and eucalyptus. The area is also known for its subsistence and semi-commercial farming systems, with many farmers engaging in seasonal sales of surplus produce.

### Socioeconomic Characteristics

Tubah is home to various ethnic groups, with a majority belonging to the Ngemba-speaking communities. The household structure is typically nuclear or extended, with average household sizes ranging from 4 to 7 persons. The population relies heavily on agriculture as the main livelihood activity, often supplemented by petty trading, remittances, and informal labour.

Most farmers operate on small landholdings averaging 1-3 hectares, often subdivided across different plots. Access to agricultural extension services, mechanization, and formal credit is limited, and community-based structures such as farmer cooperatives serve as the main institutional platform for input acquisition, information sharing, and limited market coordination.

### Relevance to the Study

Tubah was chosen as the study site because it provides:

* Widespread and diverse agroforestry practices, enabling comparative strategy modeling.
* Existing cooperative structures though underutilized for labour pooling.
* Clear labour inefficiencies linked to socio-economic and demographic factors.
* An appropriate agroecological and demographic setting to simulate scalable labour optimization interventions.

These features make Tubah an ideal location for evaluating strategies such as labour cooperatives, mechanization, and gender-based redistribution, with outcomes applicable to similar smallholder agroforestry regions across the Cameroon Highlands and beyond.

## Case Study Selection and Description

As part of the methodological approach for implementing the decision analysis on labour use efficiency optimization, this study employed an embedded single-household case study design. The aim was to analyze the practical application and simulated economic outcomes of three proposed labour optimization strategies; labour cooperatives, mechanization, and gender-based redistribution within a realistic agroforestry setting. The case study household was selected from the baseline survey data of smallholder farmers in Tubah Sub-Division, Cameroon.

### Criteria for Selection

The following selection criteria were used to identify a representative and suitable household:

* A minimum of 10 years of agroforestry experience, to ensure familiarity with long-term tree–crop integration.
* Membership in an existing cooperative, making the household eligible for potential labour-sharing initiatives.
* Active use of both family and hired labour, demonstrating current labour challenges and potential for improvement.
* A typical household size of 4-6 members, consistent with rural demographic patterns.
* Substantial productivity levels, to ensure that changes in labour use would result in measurable yield and income shifts.

### Description of the Selected Household

Based on the above criteria, one household was identified as the most suitable case for this study. The selected respondent (Farmer ID 36) resides in Big Babanki (Kedjom Keku), a key agroforestry zone in Tubah. Key features of this household are presented below:

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| --- | --- |
| **Attribute** | **Details** |
| Location | Big Babanki (Kedjom Keku) |
| Age and Gender | 60 years old, Male |
| Household Size | 4 members |
| Years Practicing Agroforestry | 10 years |
| Type of Agroforestry | Scattered trees on cropland |
| Tree Species | Tephrosia, Calliandra, Leucaena, etc. |
| Crop Types | Mixed: both food and cash crops |
| Total Farm Area | 2 hectares |
| Agroforestry Area | 0.5 hectares |
| Cooperative Membership | Active member |
| Family Labour Count | 1 worker |
| Hired Labour Used | 15 labourers per year |
| Labour Intensity | 3 activities/week, 1 man-day |
| Produce Output | 150,100 kg/year |
| Commercial Sales Share | 50% of produce sold |
| Non-Farm Income | 80,000 FCFA/month |

### Justification for Selection

This household exemplifies the labour constraints and opportunities characteristic of smallholder agroforestry systems in Tubah. Despite a relatively high yield output, the farmer relies heavily on external labour, indicating a potential gap in internal labour planning and cost efficiency. Additionally, the small agroforestry plot size (0.5 ha) provides a manageable testing ground for simulating the impacts of each intervention without introducing scale-related complexities.

The respondent's active cooperative membership supports the simulation of a cooperative-based labour-sharing model, while the use of both family and hired labour enables the modelling of trade-offs between household and external workforce use. Furthermore, the household’s structure and production level reflect the socio-economic conditions of a typical rural farm family, supporting broader applicability of the findings.

## Creating the Decision Model

A decision analysis (DA) approach, as described by Luedeling and Shepherd (2016), was used to model the decision-making context surrounding the optimization of labour use efficiency (LUE) in smallholder agroforestry systems in Tubah Sub-Division, Cameroon. This approach supports decision-making under uncertainty and provides structured insights into:

1. The impact of adopting each proposed labour optimization strategy, focusing on system profitability indicated by the Net Present Value (NPV);
2. The identification of decision-relevant uncertainties and the value of reducing those uncertainties for future policy and practice.
3. The comparative assessment of the strategies; labour cooperatives, mechanization, and gender-based labour redistribution in order to inform agricultural development stakeholders and local cooperative leaders about feasible pathways for implementation.

To achieve this, the workflow described in Do et al. (2020) was adapted and applied to the agroforestry context in Tubah. The workflow involves the development of a conceptual model of the decision system and the subsequent construction of a probabilistic simulation model to represent it. A schematic overview of the modelling process is illustrated in Figure 3.3.