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Key Regional Commodities for Social Forestry Development in Penyabungan, Mandailing Natal Regency, North Sumatra

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ABSTRACT

Social forestry is a government initiative program that promotes sustainable forest management to enhance community welfare. Mandailing Natal Regency is rich in timber and non-timber forest products (NTFP). This study aims to analyze key and non-key NTFP commodities, changes in growth patterns, and shifts within the biopharmaceutical and fruit sectors relevant to the concept of multiple-use forestry (MUF) under the framework of social forestry in Forest Management Unit IX Penyabungan, Mandailing Natal Regency. Location Quotient (LQ) and Shift-Share (SS) analysis were combined to map and identify local commodities that could become key commodities for social forestry development in Penyabungan, Mandailing Natal Regency, North Sumatra. The results indicated that cinnamon, cocoa, sugar palm, and candlenuts are the essential NTFP commodities with LQ value > 1. Meanwhile, galangal, turmeric, laos, wild ginger, and curcuma dominate the biopharmaceutical products with LQ value > 1. Among fruits, starfruit, langsat, durian, guava, jengkol, mango, mangosteen, melinjo, jackfruit, petai, rambutan, and breadfruit are identified as essential commodities with LQ value > 1. While the MUF sectors related to forestry and fruit show positive growth trends, the biopharmaceutical sector exhibits a negative shift. This study suggests that agroforestry development in the social forest at Mandailing Natal could benefit the biopharmaceutical sector, creating job opportunities and increasing farmers' incomes.

1. Introduction

Forests serve as critical ecosystems that benefit environmental health and human well-being. They provide ecosystem services such as carbon sequestration, soil and water conservation, and biodiversity preservation while supporting local communities economically and culturally (O'Brien et al. 2022). Indonesia, home to one of the world's largest forested regions, boasts unique physical landscapes, topography, and rich biodiversity, making effective forest management a national priority. As Indonesia's forests cover millions of hectares, managing these areas to maximize their environmental, economic, and social benefits is a complex yet vital task (Indrajaya et al. 2022; Nugroho et al. 2022). Effective forest management must balance these ecological benefits with the needs of communities, forest managers, and surrounding ecosystems, especially

as forests play a significant role in poverty alleviation, food security, income generation, and reducing community vulnerability (Miller and Hajjar 2020; Shyamsundar et al. 2020).

In response to these needs, Indonesia has implemented the social forestry program, a government-led initiative to promote forest conservation while improving local communities' welfare. This program is structured around three primary objectives: securing rights, enhancing livelihoods, and supporting conservation (Gunawan et al. 2022; Octavia et al. 2022). Social forestry aligns with sustainable forest management principles, where local and indigenous communities within state-owned or private forest lands manage forests. This approach aims to strengthen sociocultural dynamics, uphold environmental balance, and improve community well-being through traditional, village, community, plantation, and partnership forests (MoEF 2021; Octavia et al. 2022; Rakatama and Pandit 2020).

Recent studies have highlighted the significant potential of non-timber forest products (NTFPs) in generating economic benefits for forest-dependent communities (Delgado et al. 2023). Unlike timber extraction, NTFPs can often be harvested sustainably, offering a renewable source of income and supporting small to medium enterprises (SMEs) based on forest resources. Products such as forest honey, rattan, natural fibers and medicinal plants have local and international market potential, with demand growing for sustainably harvested natural products (Aristri et al. 2024; Roslinda et al. 2023). By integrating NTFPs into sustainable forest management plans, Indonesia can improve local economies and contribute to biodiversity conservation, creating a win-win scenario for both the environment and community welfare (Nwoboshi 2020).

The concept of multiple-use forestry (MUF) builds on these principles, encouraging communities to maximize the economic potential of forests by diversifying income streams from various forest resources (Hoogstra-Klein et al. 2017). Rather than focusing solely on timber, MUF allows the sustainable exploitation of forest commodities, including fruits, spices, medicinal plants, and NTFPs. This diversified approach enhances economic resilience within communities and contributes to the overarching goal of forest conservation. Despite challenges such as limited market access and policy constraints, MUF has the potential to substantially improve community welfare if coupled with adequate policy support and cross-sectoral collaboration (Hoogstra-Klein et al. 2017; Nwoboshi 2020).

Forest management units (FMUs) are instrumental in implementing sustainable forest management practices. FMUs are responsible for planning, organizing, implementing, monitoring, and controlling forest management activities, ensuring that these activities align with conservation and development goals (Budiningsih et al. 2017). In the Mandailing Natal Regency, FMU IX Penyabungan is a protection forest management unit focused on managing NTFPs and delivering ecosystem services (Rambey et al. 2024). Within this context, the region's forest resources are primarily geared towards NTFP production, with Forest Farmer Groups, such as Antunu Jaya and Sampean Jaya, involved in cultivating various commodities, including coffee, orange, sugar palm, durian, ginger, and galangal (Budiningsih et al. 2017; Rambey et al. 2024).

Despite the potential of these forest resources, the production and marketing efforts of the Forest Farmer Groups in Mandailing Natal remain underdeveloped (Nasution et al. 2018). Factors such as market limitations, inadequate infrastructure, and fluctuating production levels prevent these groups from fully capitalizing on the region's NTFP potential. Many commodities within Forest Management Unit IX Penyabungan are produced inconsistently, falling short of their potential in terms of quality and quantity. This inconsistency underscores the need to identify the

region's most competitive commodities to enhance marketability and promote sustainable forest-based enterprises.

This study focused on the community forests in Penyabungan, Mandailing Natal Regency, North Sumatra. According to the Central Bureau of Statistics (BPS), 8 species of NTFPs, 8 species of biopharmaceutical plants, and 22 species of fruit plants were selected as potential commodities in Mandailing Natal Regency (BPS 2020; 2021; 2022; 2023; 2024). This study aims to analyze key and non-key NTFP commodities in Mandailing Natal Regency, examining shifts in growth patterns and sectoral performance within the forestry, biopharmaceutical, and fruit sectors. By utilizing Location Quotient and Shift Share analysis, this research will provide insights into which NTFPs have the highest potential for growth and competitiveness within the social forestry and multi-business forestry framework. The results can inform strategies to optimize resource utilization and support sustainable community development within FMU IX Penyabungan, thereby strengthening Mandailing Natal's role as a sustainable forest management model in Indonesia.

2. Materials and Methods

2.1. Procedures

This research was conducted in community forests at Mandailing Natal Regency, the location of the social forestry program within FMU IX Penyabungan, North Sumatra. Social forestry, also referred to as community-based forest management, is defined as a sustainable forest management system in the state or non-state forest areas carried out by the local or indigenous communities to improve their welfare, environmental outcomes and socio-cultural dynamics (Erbaugh 2019; Rakatama and Pandit 2020). The study utilizes secondary data derived from the Gross Regional Domestic Product (GRDP), representing the total value of goods produced by each commodity in Mandailing Natal Regency and North Sumatra Province from 2019 to 2023 (BPS 2020; 2021; 2022; 2023; 2024). Data sources were obtained from relevant institutions, specifically the Central Bureau of Statistics of Mandailing Natal and North Sumatra, which are reputable economic data sources.

This research discusses the commodities within the multiple-use forestry (MUF) concept in social forestry, agroforestry, and fruit production in Mandailing Natal Regency from 2019 to 2023 (BPS 2020; 2021; 2022; 2023; 2024). A five-year data period (2019-2023) was particularly selected to ensure the validity and update data by integrating the location quotient (LQ) and shift-share (SS) analysis to map and develop programs based on identified local commodities to become key commodities for social forestry development in Penyabungan, Mandailing Natal Regency, North Sumatra. The quantitative methods used include LQ and SS analysis to assess the regional economic structure and sectoral performance over the specified period (Harjanti et al. 2021; Maspaitella et al. 2021).

2.2. Data Analysis

The determination of basis commodities in this study was conducted using LQ analysis. The integration of LQ and SS analysis becomes a relevant methodological framework, helping to map and develop programs based on local commodities (Harjanti et al. 2021; Maspaitella et al. 2021). Key aspects include how these two methods can complement data interpretation and increase

added value for local commodities to become key commodities for social forestry development in Penyabungan, Mandailing Natal Regency, North Sumatra.

The LQ values indicate the region's ability to produce specific commodities. The data for this analysis consists of GRDP figures for commodities at the regency level, including overall provincial data from 2019 to 2023. These five years were selected based on recommendations by Maspaitella et al. (2021) to avoid potential data bias, as it is advised that the analysis span at least five years for robust results. The formula for calculating LQ is Equation 1 as follows (Harjanti et al. 2021; Maspaitella et al. 2021):

$$LQ = \frac{pi/pt}{Pi/Pt} \quad (1)$$

where *pi* is the GRDP of commodity I at the local (regency) level, *pt* is the Total GRDP of all commodities at the regency level, *Pi* is the GRDP of commodity I at the provincial level, and *Pt* is the Total GRDP of all commodities at the provincial level.

The LQ analysis yields three key criteria, according to Maspaitella et al. (2021):

1. LQ > 1: This indicates that the commodity is an essential commodity, which is a source of regional economic growth. It has a comparative advantage, and its production is sufficient to meet local demand and be exported to other regions.
2. LQ = 1: This suggests that the commodity is a non-basis commodity with no comparative advantage. Its production is only sufficient to meet local demand and not for export outside the region.
3. LQ < 1: This implies that the commodity is a non-basis commodity and that its production is insufficient to meet local demand, necessitating imports from other regions.

Additionally, Shift Share Analysis was employed to identify commodities with progressive growth. The formula for this analysis, as modified from Harjanti et al. (2021) and Maspaitella et al. (2021), is expressed mathematically in Equation 2 as follows:

$$EF = RS + PS + DS$$
$$EF = \left(\frac{Yt}{Yo} - 1\right) + \left(\frac{Yit}{Yio} - \frac{Yt}{Yo}\right) + \left(\frac{yit}{yio} - \frac{Yt}{Yo}\right) \quad (2)$$
$$EF = [Ra - 1] + [Ri - Ra] + [ri - Ra]$$

where *EG* is economic growth, *RS* is regional share, *PS* is proportional shift, *DS* is differential shift, *Yo* is the national economic indicator at the start of the analysis period, *Yt* is the national economic indicator at the end of the analysis period, *Yit* is the national economic indicator for commodity i at the end of the analysis period, *Yio* is the national economic indicator for commodity i at the start of the analysis period, *yit* is local economic indicator for commodity i at the end of the analysis period and *yio* is local economic indicator for commodity i at the start of the analysis period.

The Shift-Share Analysis categorizes these components based on the framework outlined by Maspaitella et al. (2021), as shown in **Table 1**.

Table 1. Shift-share analysis categories

No	Criteria	Proportional shift	Differential shift
1	Quadran winners	Positive	Positive
2	Quadran losers	Negative	Negative
3	Quadran mixed winners	Negative	Positive
4	Quadran mixed losers	Positive	Negative

The overlay analysis was employed to identify key commodities by combining the LQ and Shift-Share analysis techniques. A commodity is classified as a basis commodity if it meets the following criteria: an LQ value greater than 1 (LQ > 1), indicating that the commodity has a comparative advantage, and the results of the Shift-Share analysis place it in the 'winners' quadrant, indicating progressive growth.

3. Results and Discussion

3.1. Analysis of Non-Timber Forest Products (NTFPs) in Forestry

The LQ analysis of NTFPs in Mandailing Natal Regency reveals that several commodities have an average LQ value greater than 1 (LQ > 1), identifying them as basis commodities. These include cinnamon (*Cinnamomum zeylanicum*), cocoa (*Theobroma cacao*), sugar palm (*Arenga pinnata*), and candlenut (*Aleurites moluccana*), all classified under the basis sector category. On the other hand, commodities with an average LQ value less than 1 (LQ < 1) include arabica coffee (*Coffea arabica*), robusta coffee (*Coffea canephora*), betel nut (*Areca catechu*), and coconut (*Cocos nucifera*) (**Table 2**). The LQ results demonstrate that the roles of cinnamon, cocoa, sugar palm, and candlenut are more prominent than those of other commodities, as indicated by their LQ values greater than 1.

Table 2. LQ Analysis results for NTFPs in social forestry MUF in Mandailing Natal Regency

Commodity	LQ	Category
Arabica coffee (*Coffea arabica*)	0.701	Non-Basis Commodity
Robusta coffee (*Coffea canephora*)	0.773	Non-Basis Commodity
Betel nut (*Areca catechu*)	0.396	Non-Basis Commodity
Cinnamon (*Cinnamomun zeylanicum*)	4.724	Basis Commodity
Coconut (*Cocos nucifera*)	0.294	Non-Basis Commodity
Cocoa (*Theobroma cacao*)	1.709	Basis Commodity
Sugar palm (*Arenga pinnata*)	1.733	Basis Commodity
Candlenut (*Aleurites moluccana*)	1.062	Basis Commodity

Note: Data from 2019–2021.

The growth of NTFP commodities in social forestry MUF in Mandailing Natal Regency from 2019 to 2021 showed a positive growth rate of 8.81%. The Proportional Shift and Differential Shift values for each commodity were positive and negative, depending on the commodity. However, the overall economic growth value remained positive, as detailed in **Table 3**. The LQ analysis reveals that the roles of cinnamon, cocoa, sugar palm, and candlenut in Mandailing Natal were more significant than those in North Sumatra Province, as indicated by LQ > 1. Conversely, arabica coffee, robusta coffee, betel nut, and coconut roles in Mandailing Natal were less prominent than in North Sumatra Province.

The classification of changes and shifts in the growth of forestry NTFP commodities in Mandailing Natal Regency for 2019–2021 is shown in **Table 4**. The Shift-Share analysis indicates that betel nut, cinnamon, and sugar palm are classified as Winners Quadrant commodities. These commodities outpaced the overall growth of the social forestry MUF sector in North Sumatra, and there was a notable shift in these commodities within Mandailing Natal due to rapid local development. This indicates that these commodities have a competitive advantage in Mandailing Natal. Overall, these commodities experienced growth in the forestry NTFP sector in Mandailing

Natal and North Sumatra. However, their increase in Mandailing Natal was less significant than in North Sumatra.

Table 3. Shift-Share analysis results of NTFP commodities in social forestry MUF in Mandailing Natal Regency

Commodity	Regional Share	Proportional Shift	Differential Shift	Economic Growth
Arabica coffee	8.816	-1.701	13.256	20.371
Robusta coffee	8.816	5.916	-11.169	3.563
Betel nut	8.816	3.341	19.986	32.143
Cinnamon	8.816	5.345	4.332	18.494
Coconut	8.816	-7.904	1.086	1.998
Cocoa	8.816	-4.470	1.203	5.549
Sugar palm	8.816	9.807	1.566	20.189
Candlenut	8.816	23.734	-23.744	8.806

Note: Data from 2019–2021.

According to Putri et al. (2020), Indonesia is one of the world's leading producers of betel nuts, with production concentrated in provinces across Sumatra and Kalimantan. Betel nut is an important export commodity, with significant destinations including India, Bangladesh, Pakistan, Malaysia, and Singapore (Azel et al. 2023). Data from the UN Comtrade Statistics 2021 shows that Indonesia was the world's top exporter of betel nut, with a production volume of 215,260 tons and a value of IDR 5.2 trillion (USD 357.46 million). Regarding cinnamon, Menggala et al. (2019) reported that cinnamon from Indonesia, especially Kerinci cinnamon, marketed under the brand name Koerintji cinnamon, is one of the most recognizable and is a buyer's favorite in the global market. Cinnamon contributes to the livelihoods of harvesters, helping to increase the gate price; however, this impacts the natural habitat of wildlife (Menggala et al. 2019). Sugar palm (*Arenga pinnata* (Wurmb) Merr.) is a natural forest species from the Palmae family that grows in most Southeast Asian countries, including Indonesia. According to Pulungan et al. (2023), there is an opportunity to develop a palm sugar industry in South Tapanuli Regency, North Sumatra, which could increase regional income for village communities. Additionally, Saediman et al. (2019) found that sugar palm farmers in the Tolowe Ponre Waru community in Southeast Sulawesi achieved an R/C ratio of 4.52, indicating significant profitability in their production processes.

Table 4. Classification of changes and shifts in NTFP commodities in social forestry MUF in Mandailing Natal Regency

Winners quadrant	Mixed winners quadrant
Betel nut	Arabica coffee
Cinnamon	Coconut
Sugar palm	Cocoa
Losers quadrant	**Mixed losers quadrant**
-	Robusta coffee
	Candlenut

Note: Data from 2019–2021.

Arabica coffee, coconut, and cocoa were classified as Mixed Winners. The growth of these commodities was slower than the overall growth of the forestry NTFP sector in North Sumatra.

However, it demonstrated a significant shift in Mandailing Natal due to rapid local development. This indicates that these commodities have a competitive advantage in Mandailing Natal. Although they experienced a decline overall, they showed increased competitiveness in Mandailing Natal. Capacity building and market access facilitation remain crucial to empowering smallholder farmers and ensuring the long-term sustainability of Sumatra's coffee industry (Fardinatri et al. 2023).

Robusta coffee and candlenuts were classified as Mixed Losers. The growth of these commodities outpaced the overall growth of the forestry NTFP sector in North Sumatra, but slower growth in Mandailing Natal led to a competitive disadvantage. Although these commodities grew overall, they remained uncompetitive in Mandailing Natal, resulting in a significant decline. Both competitive and non-competitive commodities can be utilized in agroforestry systems. The classification of changes and shifts in the growth of forestry NTFP commodities in Mandailing Natal Regency for 2019–2021 is shown in (**Table 4)**.

The Shift-Share analysis indicates that betel nut, cinnamon, and sugar palm are classified as Winners Quadrant commodities. These commodities outpaced the overall growth of the Social Forestry MUF sector in North Sumatra, and there was a notable shift in these commodities within Mandailing Natal due to rapid local development. This indicates that these commodities have a competitive advantage in Mandailing Natal. Overall, these commodities experienced growth in the forestry NTFP sector in Mandailing Natal and North Sumatra, although their increase in Mandailing Natal was not as significant as in North Sumatra.

Based on the overlay analysis, cinnamon and sugar palm were identified as key commodities in Mandailing Natal. These key commodities possess strong potential and competitive advantages, making them ideal for further development to drive economic growth. The production of cinnamon and sugar palm in Mandailing Natal is high, and both commodities have the potential to be marketed in other regions. However, it is essential to consider factors such as plant quantity, production costs, marketing channels, and external influences (e.g., exports and overproduction) that play key roles in the economic dynamics of cinnamon (Menggala et al. 2019; Qadri and Fitrisia 2023). Regarding sugar palm, Indriyani et al. (2024) found that the contribution of income from the palm sugar business to the total income of families of palm sugar entrepreneurs in South OKU Regency is 24.00%. The Forest Farmer Groups Antunu Jaya and Sampean Jaya must adjust to local agroclimatic conditions and develop partnerships with marketing networks to ensure successful production and sales processes.

3.2. Analysis of Biopharmaceutical Commodities in Social Forestry Multi-use Forestry (MUF)

The LQ analysis for biopharmaceutical commodities in the social forestry MUF in Mandailing Natal Regency identified several basis commodities with average LQ values greater than 1 (LQ > 1), including *kencur* (*Kaempferia galanga*), turmeric (*Curcuma longa*), galangal (*Alpinia galanga*), *lempuyang* (*Zingiber aromaticum*), and *temulawak* (*Curcuma zanthorrhiza*). These commodities fall into the basis sector category. On the other hand, commodities with LQ values less than 1 (LQ < 1), such as ginger (*Zingiber officinale*), Java cardamom (*Elettaria cardamomum*), and Chinese keys (*Boesenbergia rotunda*), are classified as non-basis sectors, as shown in (**Table 5**). The LQ results indicate that kencur, turmeric, galangal, lempuyang, and Java turmeric play a larger role in Mandailing Natal than other commodities, as evidenced by their LQ values greater than 1.

Table 5. LQ analysis results for biopharmaceutical commodities in social forestry MUF in Mandailing Natal Regency

Commodity	LQ	Category
Ginger (*Zingiber officinale*)	0.555	Non-basis commodity
Java cardamom (*Elettaria cardamomum)*	0.180	Non-basis commodity
Kencur (*Kaempferia galanga*)	2.192	Basis commodity
Turmeric (*Curcuma longa*)	1.389	Basis commodity
Galangal (*Alpinia galanga*)	1.421	Basis commodity
Lempuyang (*Zingiber aromaticum*)	21.957	Basis commodity
Chinese keys (*Boesenbergia rotunda*)	0.000	Non-basis commodity
Java turmeric (*Curcuma zanthorriza*)	166.323	Basis commodity

Note: Data from 2019–2023.

The growth conditions for biopharmaceutical commodities in social forestry MUF in Mandailing Natal Regency from 2019 to 2023 show a negative % growth rate of 43.63%. The proportional shift and differential shift components and overall economic growth varied across commodities, with both positive and negative values, as detailed in (**Table 6**). The LQ analysis reveals that kencur, turmeric, galangal, lempuyang, and Java turmeric play a more significant role in Mandailing Natal than North Sumatra Province, as indicated by LQ > 1. In contrast, the roles of ginger, Java cardamom, and Chinese keys are minor in Mandailing Natal compared to North Sumatra.

Table 6. Shift-share analysis results for biopharmaceutical commodities in social forestry MUF in Mandailing Natal Regency

Commodity	Regional share	Proportional shift	Differential shift	Economic growth
Ginger	-43.636	59.643	429.798	445.806
Java cardamom	-43.636	83.793	6,366.706	6,406.864
Kencur	-43.636	83.877	1,253.071	1,293.312
Turmeric	-43.636	-21.518	280.834	215.680
Galangal	-43.636	-50.172	115.842	22.035
Lempuyang	-43.636	19.237	182.360	157.960
Chinese keys	-43.636	-56.364	66.765	-33.235
Java turmeric	-43.636	323.068	-325.751	-46.318

Note: Data from 2019–2023.

The classification of changes and shifts in the growth of biopharmaceutical commodities in social forestry MUF in Mandailing Natal Regency from 2019 to 2023 is presented in (**Table 7**). The shift-share analysis identifies ginger, Java cardamom, kencur, and lempuyang as winners quadrant commodities. These commodities grew faster than the overall growth of the agroforestry sector in social forestry MUF in North Sumatra. They exhibited significant shifts within Mandailing Natal due to rapid local development. This indicates that these commodities have a competitive advantage in Mandailing Natal. Although these commodities showed growth in Mandailing Natal and North Sumatra, the increase in Mandailing Natal was less pronounced than in North Sumatra. According to Elfahmi et al. (2014), BPOM has carried out systematic and comprehensive research on nine priority plants used in biopharmaceuticals as known as jamu in

Indonesia, i.e. ginger (*Z. officinale*) and king of bitter (*A. paniculata*) as antineoplastics; turmeric (*C. domestica*), Java turmeric (*C. xanthorrhiza*) and bay cedar (*G. ulmifolia*) as antihyperlipidemic; Java noni (*M. citrifolia*), Indonesian bay-leaf (*Syzygium polyanthum*) as antidiabetics; guava (*Psidium guajava*) as antiviral; and Javanese long pepper (*Piper retrofractum*) as androgenic.

Table 7. Classification of changes and shifts in biopharmaceutical commodities in social forestry MUF in Mandailing Natal Regency (2019–2023)

Winners quadrant	Mixed winners quadrant
Ginger	Turmeric
Java cardamom	Galangal
Kencur	Chinese keys
Lempuyang	
Losers quadrant	**Mixed losers quadrant**
-	Jawa turmeric

Note: Data from 2019–2023.

Turmeric, galangal, and Chinese keys fall under the category of mixed winners. While their growth was slower than the overall biopharmaceutical sector in Social Forestry MUF in North Sumatra, they exhibited significant shifts in Mandailing Natal due to local growth. This indicates a competitive advantage in Mandailing Natal. Despite an overall decline, these commodities showed increasing competitiveness within Mandailing Natal, highlighting their growth potential.

Java turmeric was categorized as a Mixed Loser. This commodity's growth outpaced the biopharmaceutical sector's overall growth in social forestry MUF in North Sumatra. However, slower growth in Mandailing Natal resulted in a competitive disadvantage. Although temulawak exhibited overall growth, it remained uncompetitive in Mandailing Natal, leading to a decline in significance.

The overlay analysis indicates that kencur and lempuyang are the key commodities in Mandailing Natal. These key commodities have potential solid and competitive advantages, making them suitable for further development to drive economic growth. The multifunctional properties of kencur have led to increasing demand. The crop is economically important because its dry rhizomes' increased price value currently has a great export potential (Preetha et al. 2016). Rising market demand for kencur, combined with its ability to grow across various regions, has prompted farmers to expand kencur cultivation into new development areas. (Preetha et al. 2016; Saitama et al. 2023). Additionally, according to Herlina et al. (2022) the utilization of seeds and land area as production variables was neither economically nor allocatively efficient. In addition, bitter ginger (*Zingiber zerumbet*) is a medicinal plant native to Indonesia with high economic value (Geraldi et al. 2024).

Biopharmaceutical commodities are medicinal commodities derived from processing raw materials of plants, animal organs, and microorganisms that are renowned and proven to have a function for therapy or prevention of illness. Social forest areas in Mandailing Natal cover an area of 1,912.78 ha (BPS 2024). Forest fires, which can be a factor in forest health, are the most widespread in social forests. The development of policies for social forests generally considers the tourism and reforestation zones, but far less attention is given to biopharma and nature conservation zones. The concentration of governmental policies on forest zone development resulted in marginalizing the biopharmaceutical commodities managed in forest health zones.

Consequently, the well-being of biopharmaceutical commodities in social forestry areas decreased (Erbaugh 2019; Pasaribu et al. 2021)

3.3. Analysis of Fruit Commodities in Social Forestry Multi-Business Forestry (MUF)

The LQ analysis for fruit commodities in social forestry MUF in Mandailing Natal Regency identified several basis commodities with average LQ values greater than 1 (LQ > 1), including starfruit (*Averrhoa carambola*), langsat (*Lansium domesticum*), durian (*Durio zibethinus*), guava (*Psidium guajava*), jengkol (*Pithecellobium jiringa*), mango (*Mangifera indica*), mangosteen (*Garcinia mangostana*), melinjo (*Gnetum gnemon*), jackfruit (*Artocarpus heterophyllus*), *petai* (*Parkia speciosa*), rambutan (*Nephelium lappaceum*), and breadfruit (*Artocarpus altilis*). These commodities fall into the basis sector category, as shown in (**Table 8**). Meanwhile, commodities with LQ values less than 1 (LQ < 1), such as avocado (*Persea americana*), water apple (*Syzygium aqueum*), pomelo (*Citrus grandis*), Siam orange (*Citrus nobilis*), pineapple (*Ananas comosus*), papaya (*Carica papaya*), banana (*Musa paradisiaca*), snake fruit (*Salacca zalacca*), sawo (*Manilkara zapota*), and soursop (*Annona muricata*), are considered non-basis sectors.

Table 8. LQ Analysis results for fruit commodities in social forestry MUF in Mandailing Natal Regency

Commodity	LQ	Category
Avocado (*Persea americana*)	0.210	Non-basis commodity
Starfruit (*Averrhoa carabola*)	5.062	Basis commodity
Langsat (*Lansium domseticum*)	1.720	Basis commodity
Durian (*Durio zibetinus*)	1.146	Basis commodity
Water apple (*Syzygium aqueum*)	0.626	Non-basis commodity
Guava (*Psidium guajava*)	1.033	Basis commodity
Jengkol (*Pithecellobium jiringa*)	1.744	Basis commodity
Pomelo (*Citrus grandis*)	0.000	Non-basis commodity
Siam orange (*Citrus nobilis*)	0.162	Non-basis commodity
Mango (*Mangifera indica*)	2.604	Basis commodity
Manggosteen (*Garcinia mangostana*)	6.082	Basis commodity
Melinjo (*Gnetum gnemon*)	3.028	Basis commodity
Jackfruit (*Arthocarpus heterophyllus*)	4.626	Basis commodity
Pineapple (*Ananas comosus*)	0.000	Non-basis commodity
Papaya (*Carica papaya*)	0.325	Non-basis commodity
Petai (*Parkia speciosa*)	6.098	Basis commodity
Banana (*Musa paradisiaca*)	0.227	Non-basis commodity
Rambutan (*Nephelium lappaceum*)	2.689	Basis commodity
Snakefruit (*Salacca zalacca*)	0.001	Non-basis commodity
Sawo (*Manilkara zapota*)	0.085	Non-basis commodity
Soursop (*Annona muricata*)	0.262	Non-basis commodity
Breadfruit (*Artocarpus altilis*)	1.051	Basis commodity

Note: Data from 2019–2023.

The growth of fruit commodities in social forestry MUF in Mandailing Natal Regency from 2019 to 2023 showed a positive growth rate of 181%. The proportional shift, differential shift, and economic growth values varied across commodities, with both positive and negative trends, as detailed in (**Table 9**). The LQ results reveal that the roles of starfruit, langsat, durian, guava,

jengkol, mango, mangosteen, melinjo, jackfruit, petai, rambutan, and breadfruit in Mandailing Natal are more significant compared to North Sumatra Province, indicated by LQ > 1. In contrast, avocado, water apple, pomelo, Siam orange, pineapple, papaya, banana, snake fruit, sawo, and soursop play more minor roles in Mandailing Natal than North Sumatra. Several fruit trees, including avocado, durian, melinjo, jackfruit, mango, nutmeg, petai, breadfruit, and clove, are intolerant species with diverse canopy strata, which should be considered in agroforestry cultivation (Ramadhani et al. 2023).

Table 9. Shift-Share Analysis results for fruit commodities in social forestry MUF in Mandailing Natal Regency

Commodity	Regional share	Proportional shift	Differential shift	Economic growth
Avocado	181.79	-3.75	3.18	181.22
Star Fruit	181.79	52.04	-240.57	-6.73
Langsat	181.79	-82.32	-49.56	49.91
Durian	181.79	-58.80	-74.72	48.28
Water Apple	181.79	-51.70	-155.10	-25.01
Guava	181.79	-106.00	-43.42	32.38
Jengkol	181.79	98.65	-117.42	163.03
Pomelo	181.79	-281.79	24.92	-75.07
Siam Orange	181.79	-118.83	-14.33	48.64
Mango	181.79	176.36	-326.13	32.03
Manggosteen	181.79	0.47	-119.45	62.81
Melinjo	181.79	16.91	-157.23	41.48
Jackfruit	181.79	-35.45	-118.36	27.98
Pineapple	181.79	-221.27	76.24	36.76
Papaya	181.79	22.00	-181.52	22.28
Petai	181.79	315.88	-297.49	200.18
Banana	181.79	-161.83	-4.51	15.45
Rambutan	181.79	-33.10	-119.56	29.14
Snake fruit	181.79	-153.99	7.13	34.94
Sawo	181.79	55.63	-81.82	155.60
Soursop	181.79	-140.62	10.56	51.74
Breadfruit	181.79	0.911	-76.86	105.85

Note: Data from 2019–2023.

Fruit cultivation in social forestry entered the early stages of establishing social forestry. In Mandailing Natal, according to the available forest area allocation, it has entered 69 villages or 46.17% of the total village (BPS 2024). The distributed fruits consist of 1,819 mango trees, 348 rambutan trees, 1,967 langsat trees, 1,348 durian trees, and 886 mangosteen trees ready for production. Modern farming systems show that tropical fruits are grown between forests and crops. In Indonesia, fruits have a special place in society. Trees take time to grow and produce fruits, and forests often take a long time to recover and mature. Market problems are influenced by the type and price of fruits produced, how much it costs to bring products to the market, and so forth. The development of agroforestry in the social forest at Mandailing Natal is part of the government policy to overcome deforestation and to provide benefits for the surrounding people. Also, this program aims to create job opportunities and increase farmers' incomes. Social forestry

development at Mandailing Natal has been implemented since 2013, and most farmers have activities of plants producing export commodities of fruits (BPS 2020; 2021; 2022; 2023; 2024).

The classification of changes and shifts in the growth of fruit commodities in social forestry MUF in Mandailing Natal Regency from 2019 to 2023 is presented in (**Table 10**). The Shift-Share analysis indicates mixed winners: avocado, pomelo, pineapple, snake fruit, and soursop. The growth of these commodities was slower than the overall growth of the fruit sector in social forestry MUF in North Sumatra. However, they showed a significant shift in Mandailing Natal due to rapid local development. This indicates that these commodities have a competitive advantage in Mandailing Natal. Although these commodities experienced a decline overall, they exhibited increasing competitiveness in Mandailing Natal. Starfruit, jengkol, mango, mangosteen, melinjo, papaya, petai, sawo, and breadfruit have been categorized as Mixed Losers. While these commodities have grown faster than the overall fruit sector in social forestry MUF in North Sumatra, their slower growth in Mandailing Natal has led to a competitive disadvantage. However, it is worth noting that mangosteen, melinjo, and avocado have shown significant roles and potential for economic growth in West Java. Langsat, durian, water apple, guava, siam orange, jackfruit, banana, and rambutan were classified as Losers Quadrant commodities. These commodities grew slower than the overall growth of the fruit sector in social forestry MUF in North Sumatra and exhibited significant shifts due to slower growth in Mandailing Natal. This indicates that these commodities are uncompetitive in Mandailing Natal, with an overall decline in their growth in Mandailing Natal and North Sumatra. However, the decline in Mandailing Natal was less severe than in North Sumatra.

Table 10. Classification of changes and shifts in fruit commodities in social forestry MUF in Mandailing Natal Regency

Winners Quadrant	Mixed Winners Quadrant
	Avocado
	Pomelo
	Pineapple
	Snake fruit
	Soursop
Losers Quadrant	**Mixed Losers Quadrant**
Langsat	Starfruit
Durian	*Jengkol*
Water Apple	Mango
Guava	Mangosteen
Siam Orange	*Melinjo*
Jackfruit	Papaya
Banana	*Petai*
Rambutan	*Sawo*
	Breadfruit

Note: Data from 2019–2023.

Based on the overlay analysis, no fruit commodities in Mandailing Natal are currently classified as key commodities. However, if only LQ > 1 is considered, the key fruit commodities in Mandailing Natal are starfruit, langsat, durian, guava, jengkol, mango, mangosteen, melinjo, jackfruit, petai, rambutan, and breadfruit. According to Qurniati et al. (2017), multi-purpose tree species (MPTS) like fruits can provide long-term income because they are harvested yearly, while plantation and crops offer short-term income.

3.4. Potential Commodities for Social Forestry Multi-Business Forestry (MUF) Development in KPH IX Penyabungan

Social forestry development requires an implementation strategy to optimize the economic feasibility of the people of Mandailing Natal regency. Although all the plants studied produced potential commodities, the highest economic feasibility is focused on fruit commodities. In rural social forestry areas, many commodities and few people are involved in its utilization. This could be an opportunity to provide agricultural or industrial business strategies with high economic feasibility values. On the other hand, funding and the willingness to use and develop the potential commodities of the community are two important factors that must be considered and prepared carefully.

LQ and SS analysis has identified significant potential for non-timber forest products (NTFP) and agroforestry development in Mandailing Natal. This potential is particularly promising for commodities such as cinnamon, cocoa, sugar palm, and candlenut in the NTFP sector and kencur, turmeric, galangal, lempuyang, and Java turmeric in the agroforestry sector. The recommended fruit commodities for alternative development are starfruit, langsat, durian, guava, jengkol, mango, mangosteen, melinjo, jackfruit, petai, rambutan, and breadfruit. The ideal agroclimatic conditions for developing NTFP in Forest Farmer Groups Sampean Jaya and Antunu Jaya in Mandailing Natal Regency include high and evenly distributed rainfall, temperatures ranging from 22–30°C, and high humidity. These conditions are highly favorable for the optimal growth of NTFPs such as agarwood, benzoin, and various fruit species (Pasaribu et al. 2021; Sribudiani et al. 2024). The supportive topography and fertile soil further contribute to the productivity and sustainability of NTFPs. The two forest farmer groups also have close-knit communities firmly rooted in local wisdom. However, limited access to markets, technology, and capacity-building resources remain significant barriers to fully maximizing NTFP potential. Forest product processing-based community companies have proven financially viable when given the necessary tools, machinery, manufacturing space, and training. However, fortifying the marketing sector throughout the follow-up phase is crucial to supply the final products while the manufacturing sector evolves and improves (Harbi et al. 2023).

Agroforestry, an intensive land management system that integrates forestry and crops, is a key approach that Forest Farmer Groups in FMU IX Penyabungan can adopt. This system maximizes productivity and ensures land conservation and practical cultivation for local communities. As a priority program under the Ministry of Environment and Forestry, agroforestry is vital in supporting forest management activities, such as the Social Forestry Program (MoEF 2016). Developing agroforestry requires a well-planned model that meets three critical criteria: productivity, sustainability, and adaptability (Birla et al. 2024; Duffy et al. 2021). The concept of agroforestry is not new because it is very close to the life system of the Mandailing people, and it has been practiced for generations in a way that does not damage the environment. People plant fruit trees in forests and gardens. That is a good record and needs to be preserved in a better and more scientific way of cultivation, especially in social forestry.

The management of land for MUF, particularly agroforestry, must also align with the cultural practices of the surrounding community. Local key species often developed on agroforestry land are influenced by traditional practices, local culture, and the socio-economic considerations of the community. According to Wulandari et al. (2014) and Wulandari et al. (2018), local communities prefer MPTS, such as fruit trees, which offer dual benefits in meeting their livelihood needs. For

example, a study by Rahmawaty et al. (2023) found that the utilization of MPTS or plantation and industrial plants like durian, avocado, guava, candlenut, cinnamon, eucalyptus can increase the economic value and profitability of coffee-based agroforestry land in Toba Regency, North Sumatra. Conversely, according to Premono et al. (2018), a study on the Agroforestry of coffee plants and marrango trees in Bengkulu was financially feasible at an 8% discounted rate. The NPV, BCR, and IR were IDR 76,250,582, 2.28, and 22%, respectively.

Additionally, agroforestry can benefit from the cultivation of biopharmaceutical crops. Zingiberaceae family plants, such as rhizomes, are characterized by ease of cultivation, making them widely grown by local communities in home gardens or upland fields (Nahlunnisa et al. 2015). By adopting agroforestry techniques, forest-adjacent communities can improve their socio-economic conditions while ensuring sustainable forest management (Qurniati et al. 2017). Agroforestry crops that can provide short-term income include chili (*Capsicum* sp.), ginger (*Zingiberis rhizoma*), cocoa (*Theobroma cacao*), coffee (*Coffea arabica*), turmeric (*Curcuma longa*), rice (*Oryza sativa*), banana (*Musa* sp.), celery (*Apium graveolens*), lemongrass (*Cymbopogon nardus*), and tomato (*Solanum lycopersicum*) (Aprianto et al. 2016; Kaskoyo et al. 2014; Kholifah et al. 2017; Qurniati et al. 2017). Considering the range of potential key commodities, each forest farmer group in FMU IX Penyabungan can adapt MUF development to the local culture and practices. According to Rajagukguk et al. (2018), the selection of plant species and cropping patterns is influenced by income potential, production continuity, production speed, ease of maintenance, local culture, and plant capabilities.

4. Conclusions

The key NTFP commodities in Mandailing Natal Regency are cinnamon, cocoa, sugar palm, and candlenut. The key biopharmaceutical commodities include kencur, turmeric, galangal, lempuyang, and Jawa tumeric. The key fruit commodities are starfruit, langsat, durian, guava, jengkol, mango, mangosteen, melinjo, jackfruit, petai, rambutan, and breadfruit. The shifts and changes in NTFP and fruit commodities in Mandailing Natal showed overall positive trends, whereas biopharmaceutical commodities experienced negative growth. Mandailing Natal is competitive in cinnamon, sugar palm, kencur, and lempuyang. Production development in Forest Farmer Groups Antunu Jaya and Sampean Jaya can be enhanced by adopting agroforestry systems with recommended basis commodities. To accelerate the development of these basis commodities, targeted investments in agricultural and forestry infrastructure should be made. Further research should focus on optimizing the basis commodities of Mandailing Natal to strengthen competitive business advantages, increase income, and project future employment generation.

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Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation

During the preparation of this work the authors used Grammarly in order to write more scientific soundness. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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