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DETERMINANTS AND STRATEGIES TO INCREASE COCONUT SAP PRODUCTIVITY BASED ON COMMUNITY EMPOWERMENT IN THE KOKAP DISTRICT AREA, KULON PROGO, YOGYAKARTA, INDONESIA

IRENE P. CAHYANI[1]*, MASRUR ALATAS[2], AGUS SUYANTO[2], CHAFID FANDELI[2] AND H. NASIRUDIN[2]

[1]Master of Environmental Science, Post Graduate Faculty, Institut Teknologi Yogyakarta, Gedongkuning, Banguntapan, Bantul, 55198, Daerah Istimewa Yogyakarta, Indonesia. [2]Post Graduate Faculty, Institut Teknologi Yogyakarta, Gedongkuning, Banguntapan, Bantul, 55198, Daerah Istimewa Yogyakarta, Indonesia.

**Corresponding author: ipcahyani@gmail.com*

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LPPM ITY: Institute for Research and Community Service Institute Technology Yogyakarta

ABSTRACT

Strong dependence on rainfall and the inability to adapt to extreme climate change have led to a continued decline in agricultural output and farmer income in the Kokap District. The purposes of this study were to determine the pattern of community empowerment in increasing coconut sap productivity and to develop farmer strategies for increasing coconut sap productivity. The research method employs a qualitative, descriptive approach, using the KoboToolbox and GIS mapping. Sampling is conducted in all hamlets with coconut sap tappers. Data were collected through interviews with 100 coconut sap farmers from three villages, observations, and literature reviews to determine land characteristics and patterns of community empowerment in increasing coconut sap productivity. The results of the study indicate that the capability and suitability of land for coconut planting are important, as are effective community empowerment patterns. The solution is to recommend farmer strategies both technically and non-technically, without ignoring the importance of maintaining the environment and its sustainability.

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Introduction

Kokap District is located in a protected conservation area and is home to thousands of indigenous small-scale farming communities whose livelihoods are largely dependent on rain-fed agroforestry production systems. The strong dependence on rainfall and the inability to adapt to extremes of climate change have led to a continued decline in agricultural yields and farmer incomes. This trend has worsened the socioeconomic position of farming households and remains a major contributor to poverty, food insecurity, malnutrition, and job losses. The problems can stem from external factors such as more extreme weather events, while internal factors reflect poor agroecological practices and a lack of adaptive strategies. This is emphasised by Ram *et al*. (2020), who note that crop yield stability is highly dependent on plant characteristics, such as resistance to environmental stresses such as water stress and high temperatures (humidity).

Smallholder farmers in the Kokap District have not been able to adequately adapt their farming practices to changing conditions caused by climate change, including extreme events such as inter-seasonal dry seasons and excessive droughts and floods. Multi-hazard

risk mapping in Kulon Progo concluded that the most hazardous areas in Kokap District are in the western highlands. Kokap receives high rainfall from November to March after the dry season begins. Climate change is now affecting rainfall rates, leading to drier seasons and inter-seasonal droughts. Farmers in the area have no coping mechanisms for their lands being flooded during the rainy season, only to suffer prolonged droughts immediately after. Poor harvests in previous seasons have led to economic deficits that must be financed for the next planting season, fueling a vicious cycle of poverty.

The importance of environmental conditions, particularly temperature and relative humidity during postharvest handling, is highlighted by the finding that maintaining relative humidity below 85% may help preserve coconut sap quality (Rahayoe *et al.*, 2025) increasingly recognized as a functional sweetener, is highly perishable and influenced by environmental conditions during postharvest handling, yet the specific impacts of microclimatic variables such as temperature and relative humidity (RH. The other research using the Taguchi method in Thailand during the rainy season also found the importance of environmental conditions for coconut sap quality after harvesting (Wiboonsirikul *et al.*, 2024) various experiments were designed, including authorities in the area have not been able to adequately address these issues due to limited budget and administrative capacity. The main issues to address are agroecological challenges that hinder agricultural productivity and market challenges that hinder efficient value chains.

Coconut sugar farmers in Kokap District have been around for a long time, as has the coconut sap that is collected/tapped. According to information/stories from the community/ farmer tappers, the yields of coconut sap have decreased compared to several years ago. The productivity of small-scale organic coconut farmers in Kulon Progo has always been low. The productive capacity of agroforestry systems has decreased alongside farmers' income levels. The absence of climate-smart agriculture, coupled with poor land management practices and worsening extreme weather events, has forced many people to switch to subsistence farming and led to poverty. According to the global Organic Coconut Sugar market report (Maia, 2023), the market was valued at USD5,598.54 million and is projected to reach USD7,773.43 million by 2028, with a 5.62% annual growth rate. Indonesia has more than 100,000 coconut sugar producers, supplying around 50,000 metric tons of coconut sugar to the domestic market each month. The demand from the global market for Indonesian organic coconut sugar is also increasing rapidly, from 25,000 metric tons in 2017 (USD42.68 million) to more than 41,000 metric tons in 2021 (USD73.86 million) (Mediaperkebunan.id, 2022). Therefore, the objective is to increase the productivity of coconut sap. Researchers intend to implement community-based management of coconut trees, and it is hoped that these results will serve as an example in other places with the same problems.

Materials and Methods

Study Area

The location for this study is in Kokap District, Kulon Progo Regency. The research period ran from May to early August 2024. From the Kokap District, five villages were selected: Hargowilis Village, Hargotirto Village, and Kalirejo Village (Figure 1).

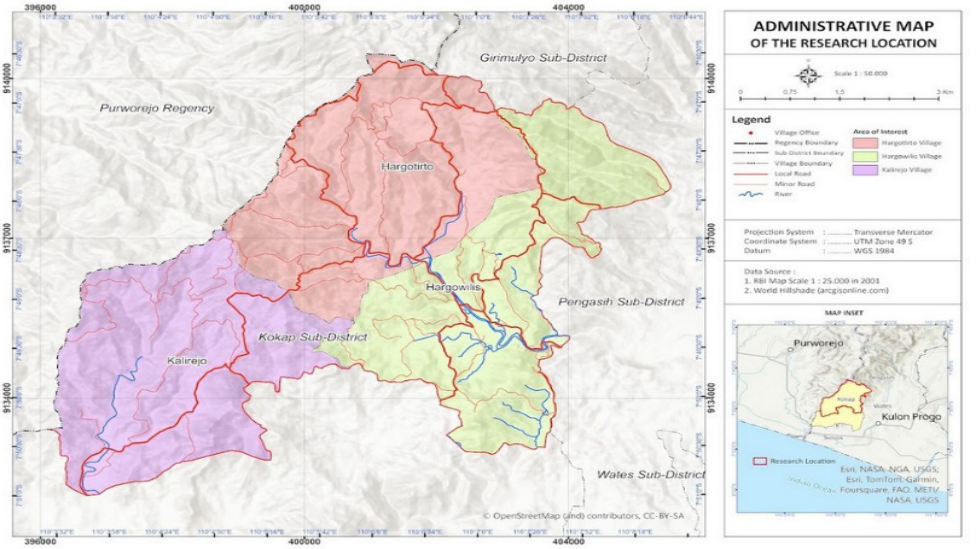


Figure 1: Map of study location

Research Methods

Research Design

There are quantitative (sampling of 100 coconut sap tappers from three villages) and some qualitative data collection, such as a questionnaire using the Kobotoolbox app, soil sample testing, and observation of land characteristics.

Data Collection

Researchers conduct a sampling of 100 coconut sap tappers from 3 existing villages (30 farmers from Hargotirto village, 30 farmers from Hargowilis village, and 40 farmers from Kalirejo village) who are representatives of the existing hamlets to be interviewed using questionnaires to collect initial data before the intervention is carried out using the kobotoolbox application.

Data Analysis

Soil samples and laboratory tests are conducted to determine the nutrient content (N, P, K, Ca, and Mg) in the soil surrounding coconut trees. Based on these data, recommendations can be developed to help farmers improve soil nutrient levels. Additionally, land characteristics are assessed using land capability and suitability maps to evaluate the appropriateness of the land for coconut cultivation. The extent of community empowerment in the three villages is also examined to assess the effectiveness of farmer strategies in increasing coconut sap productivity.

Results and Discussions

From the topographic map (Figure 2), we can see that the research locations of the three villages have quite extreme terrain: A hill with rather steep slopes, with a small section that is very steep.

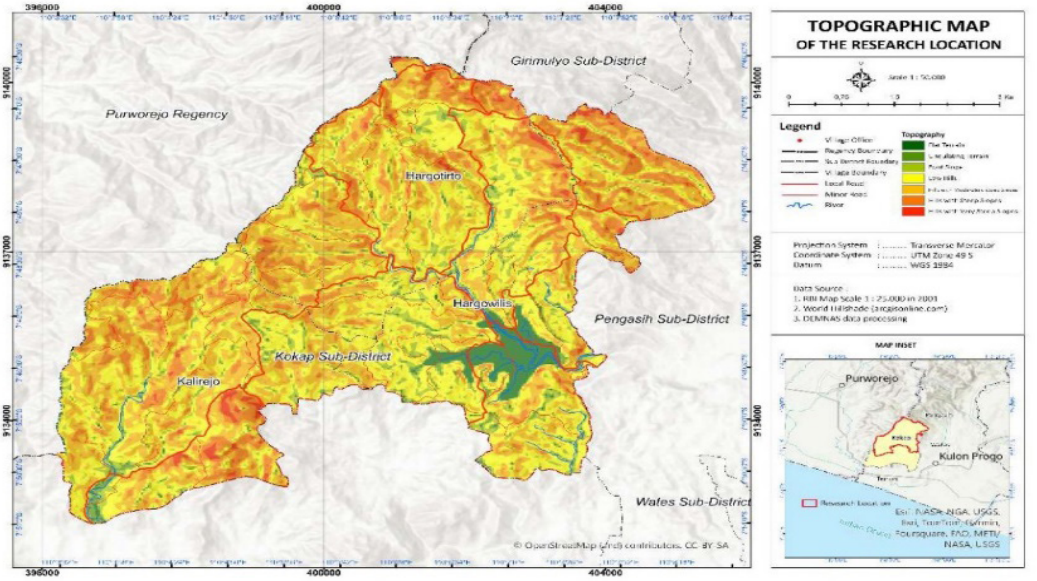


Figure 2: Topography map

Besides that, from Table 1 we can see the result of 10 soil sample analyses from three villages

Table 1: Soil sample analyses

No.	Sample Code	pH	N Total (%)	P_2O_5 (ppm)	K	Ca	Mg
					… (Cmol(+)/kg) …		
1	Agus S. Purnomo (Tegiri 1/Hargowilis)	6,36	0,15	10,22	0,36	24,08	0,59
2	Teguh Wiyadi (Sidowayah/Hargowilis)	5,85	0,13	8,81	1,31	22,76	0,37
3	Sukini (Clapar 1/Hargowilis)	6,88	0,36	65,61	0,96	31,04	2,05
4	Sadali (Segajih/Hargotirto)	6,71	0,29	45,21	0,82	30,06	1,88
5	Mardiyah (Menguri/Hargotirto)	6,85	0,25	35,12	0,64	29,09	1,61
6	Ngatiman (Sebatang/Hargotirto)	5,88	0,20	19,63	0,81	28,77	1,04
7	Warsiyah (Kalibuko 2/Kalirejo)	6,05	0,25	34,03	1,28	29,08	1,48
8	Sukadi (Kalibuko 1/Kalirejo)	7,17	0,37	53,79	0,49	30,07	1,97
9	Parmi (Papak/Kalirejo)	6,26	0,16	11,30	0,57	24,52	0,74
10	Tulusman (Sangir/Kalirejo)	5,71	0,19	14,29	0,36	27,79	0,87

From the analysis of 10 soil samples, we attempted to spatialise them relative to land topography in the three villages, as shown in Figure 3.

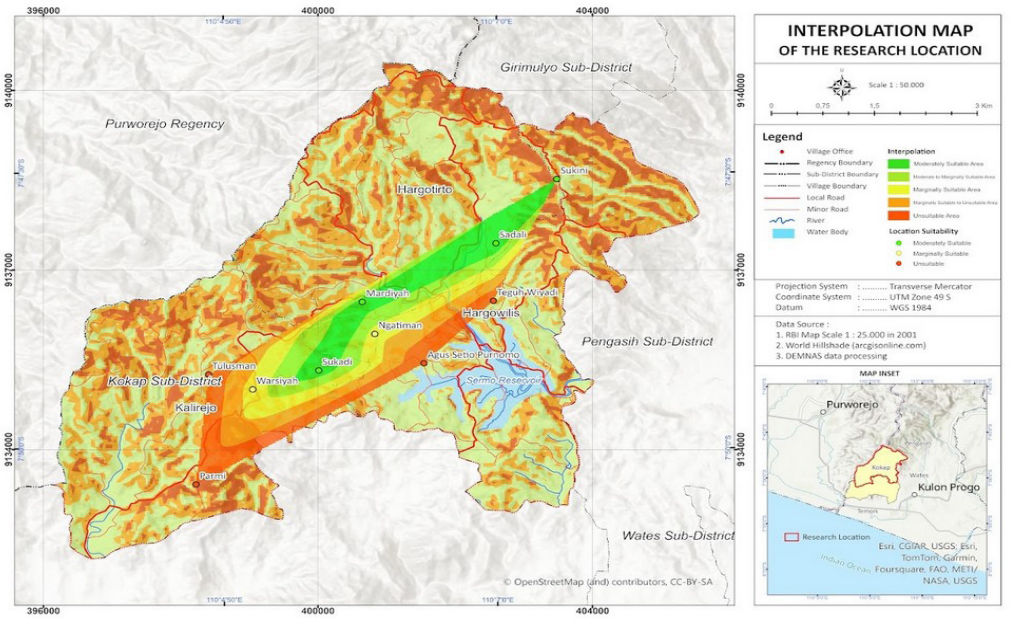


Figure 3: Research location interpolation map

The spatial analysis indicates that four sample locations are suitable for coconut cultivation. Although these sites are situated in relatively elevated hamlets, the soil samples were collected from flat terrain, suggesting that the sampling areas may accumulate topsoil from higher ground. Two additional sites are less suitable due to their acidic soil pH. The remaining four locations are unsuitable due to both acidic pH and insufficient macro-nutrient levels.

Following the observation that both topographical features and the analysis of 10 soil samples from the three villages did not meet the requirements for coconut cultivation, the researchers consulted additional sources to determine the optimal conditions for coconut growth. These conditions are presented in the table below, along with a figure illustrating the average rainfall in Kulon Progo.

Table 2: Coconut growing conditions

Land	Ideal height < 600 m above sea level, land slope < 45^{o}
Soil	Sandy soil, sandy loam, slightly clayey with pH 5.2 to 8, a crumbly structure, so that roots develop well
Temperature and eeather	The most suitable temperature is 27 ^{o}C, with an average variation of 5 ^{o}C to 7 ^{o}C, minimum sunlight 120 hours per month
Rainfall	Good rainfall 1,300 to 2,300 mm per year, long drought causes production to decrease by 50%, high humidity causes fungal disease attacks

Source: Nur *et al.* (2024) and Barnet (2023)

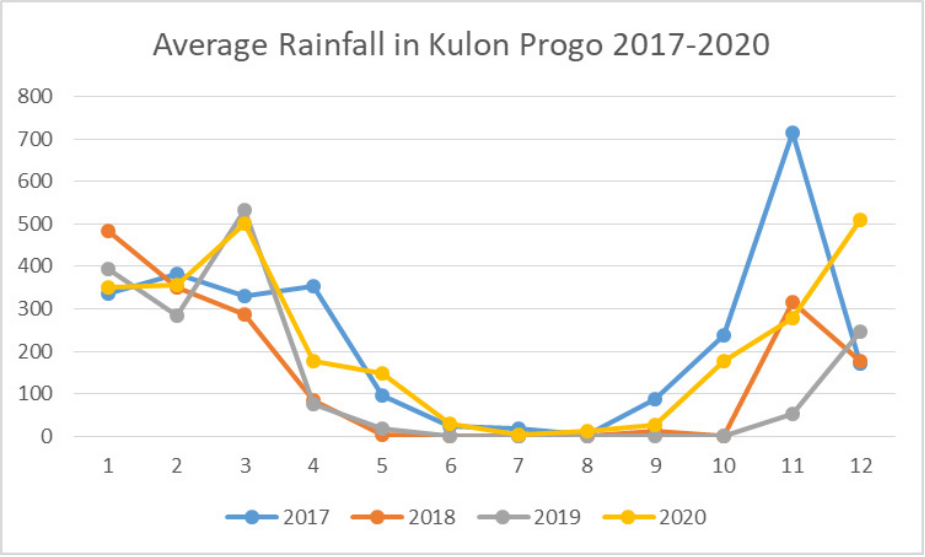
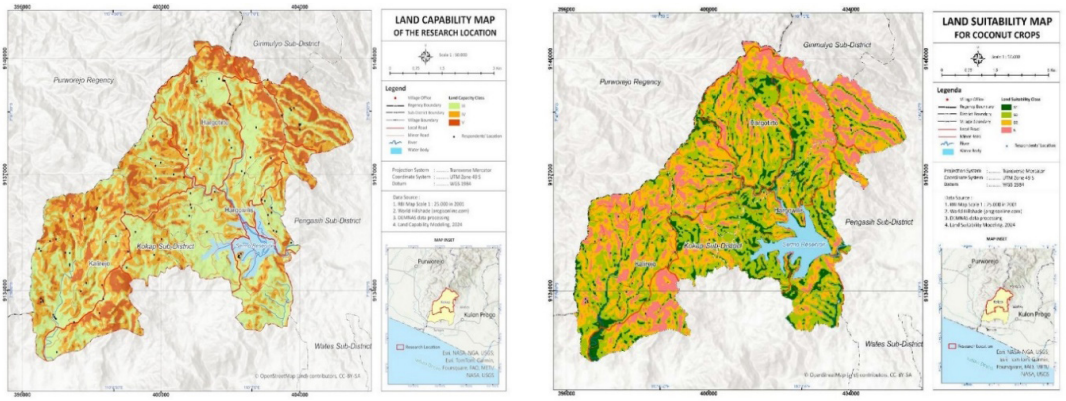


Figure 4: Average rainfall in Kulon Progo

Fremond *et al.* (1966) stated that coconut plants require a minimum monthly rainfall of 130 mm and a dry season of no more than 3 months. In Indonesia, most coconut plantations are on dry land, so coconut plants' water needs are met by rainfall. The annual rainfall required for optimal coconut growth and production ranges from 1,500 to 2,500 mm (Djaenudin *et al.*, 2011). From the average rainfall in Kulon Progo, we can see that the monthly rainfall from year to year is decreasing with six months of dry season. Each coconut tree requires 55 to 120 litres/day of water and good rainfall of 1,300 to 2,300 mm/year, so we can conclude that rainfall availability is very limited. In addition, the coconut trees in the three villages do not have the ideal spacing for coconuts, worsening the condition of the existing trees.

In addition, researchers examined land capability and suitability in the three villages, with the following results (Figure 5).



(a) (b)

Figure 5: (a) Land capability map and (b) land suitability map

The analysis results for land capability and suitability maps are as follows.

Table 3: Land capability and land suitability analysis

Land Capability	Land Suitability
There are more constraints to agricultural use. Constraints are one or a combination of the following factors: steep slopes or very sensitive to erosion, poor drainage, very slow permeability, shallow soil, very low water-holding capacity, low fertility, and difficult to repair.	Land has severe limiting factors that will greatly affect its productivity, requiring additional inputs.
Land use options are more limited. Limiting factors: One or a combination of steep slopes, highly susceptible to erosion, shallow solum, low water holding capacity, and poor drainage. Requires special management that is relatively difficult.	And also land that is not suitable because it has very heavy and/or difficult limiting factors.
Found in almost flat, wet or waterlogged places, or with lots of rocks on the surface; for example, land in depressions and rocky land.	Overcoming limiting factors requires significant capital, so there needs to be assistance or intervention from the government or the private sector.

Observation activities were conducted in three villages while interviewing coconut tappers, both male farmers who tap coconuts and female farmers who usually cook the tapped coconut sap. The results of observations and interviews related to community empowerment in three villages: researchers interviewed 51 male respondents and 49 female respondents across 33 hamlets in Kokap Subdistrict.

In addition, researchers sought information from other locations on community empowerment patterns to compare with those found in the 3 research villages; the results are shown below.

Table 4: Empowerment patterns in Kokap compared to those in Banyumas and Banyuwangi

Rancamaya Village, Banyumas	Sambimulyo Village, Banyuwangi	Three Villages in Kokap Subdistrict
The life of the tappers or coconut farmers is still far from prosperous. This is based on their limited circumstances, as they are unable to control prices that are often monopolised by the parties in power. This condition is also still experienced by the tappers in Banyumas Regency, one of the areas that is the centre of coconut sugar production in Indonesia (Badriah *et al.*, 2022).	In Sambimulyo Village, in general, processed coconut sugar products at the farmer level and in home industries are still of low quality. The products produced only have one conventional form (plastic bowl mould) with the colour of the coconut sugar produced being dark brown, the weakness of this product is that it has a less than optimal level of durability, namely it is easily watery or melts (Cahyantini *et al.*, 2017).	There is assistance in two villages (Hargowilis and Hargotirto) to ensure that coconut sugar production is in accordance with standards. In Kalirejo village there has been no assistance, but the results are stable.

Limited knowledge and inability to access the market leave coconut sugar farmers dependent on collectors and unable to determine the product's price. Dependence on collectors leaves farmers in a weak bargaining position, so the selling price of coconut sugar often fluctuates.		There is clear market access, as the coconut sugar produced in the three villages in the Kokap subdistrict is directly purchased by the private sector at a higher price than the local market price.
Farmer groups and cooperatives were formed to support the development of coconut sugar businesses and to serve as forums for strengthening the solidarity of coconut tappers and building group independence.	There is a community service to provide temporary assistance to improve packaging and increase the selling value.	These three villages are composed of individual farmers, without cooperatives or farmer groups, but in Hargowilis Village and Hargotirto Village, assistance from the private sector helps maintain quality in accordance with international standards. In Kalirejo Village, even without assistance, the results are directly purchased by the private sector.

Based on the results mentioned above, we can conclude which shortcomings exist and what the farmers' strategies are to address them, as follows.

Table 5: SWOT analysis

Topic	Weaknesses	Strength	Opportunities	Threats
Land characteristics (land capability and suitability), soil analysis results	There are more inhibiting and limiting factors for agricultural land use.	Technical treatment (provision of dolomite and organic fertiliser, and making water trap, as well as terracing using an A-frame)	Proposing the relevant agency to obtain assistance with dolomite and organic fertiliser	The budget from the relevant agency is insufficient to meet needs, and the three villages are not a priority for the agency.
Community Empowerment Pattern	1 village has no assistance, still individual farmers,	There is assistance from the private sector in 2 villages	Non-technical treatment (assistance from the private sector and also involvement of other stakeholders such as LPPM ITY, and related agencies), distribution of leaflets, and installation of banner stands in public facilities	Changes in standard rules from abroad for exports have changed

Sustainability	Extension officer is not optimal and does not focus on coconuts	There are private sectors	There is clear market access and certification	Sugar price competition between the private sector

Note: The SWOT analysis in Table 5 refers to the collaborative *Pentahelix* approach proposed by Alatas *et al.* (2022), which involves five key stakeholders: the community, the private sector, academia, government, and the media. In this context, strengths and opportunities reflect community and private-sector engagement, while weaknesses and threats highlight limited government support and regulatory challenges.

The details of the technical treatment, including the function and steps, as in Table 6.

Table 6: Technical treatment, functions, and steps

Technical Treatment	Function	Steps
Dolomite	To increase the pH	Apply 0.25 kg per tree every three months and at a distance of about 1 m from the tree trunk.
Organic fertiliser	Can help the process of improving soil structure, increasing the soil's water absorption capacity, increasing the life of organisms in the soil, improving the chemical properties of the soil such as pH and nutrient content	1. All materials are collected according to the Green category (green leaves from gamal, lamtoro, kaliandra, petai, or other leaves and banana stems), Brown (dry leaves, dry twigs, sawdust), and dried animal waste 2. Finely chop large and hard materials 3. Make a composting box on the ground measuring 1 m x 1 m x 1 m 4. For 1 tonne of fertiliser, 1 L of EM4 solution is needed which is dissolved in 200 L of water with 1 kg of coconut sugar. Meanwhile, for 1 m^3 weighing 100 kg, 100 ml of EM4 solution is needed, dissolved in a mixture of 100 grams of coconut sugar. You can also replace the coconut sugar with molasses 5. Place each ingredient in a regular order, starting from any category, namely - layer 1: Greens, brown, dirt, solution water that is sprinkled evenly - layer 2: Greens, brown, dirt, solution water that is sprinkled evenly - layer 3: etc. until it reaches 1 m 6. After all layers are arranged 1 m, cover them with a tarpaulin/plastic sack (if made in a hole). If it is the rainy season, it is better to make it in plastic/tarpaulin so that rainwater does not enter 7. Temperature observation and turning are carried out every 2 times a week, turned over if it is too hot, water is added, but if it is too cold, brown ingredients are added 8. Observe until the level of maturity: no smell, dark brown colour, the intact shape of the ingredients is no longer visible (already destroyed), and low temperature
Jogangan/ rorak (Water trap)	Can be used as a place for plant remains and also to collect rainwater	It is made around coconut trees or terraces with sizes adjusted to needs
Making a terrace using an A-frame	Reduces erosion and landslides and makes land cultivation easier	This A-frame looks like an isosceles triangle, but this tool functions to determine the direction of the contour which is equipped with a thread and weights as a balancer for the flat surface (water pass)

Conclusions

The land capability and suitability of three villages in Kokap District are still far from optimal for coconut planting, resulting in suboptimal yields. A good and recommended community empowerment pattern is continuous assistance from the private sector located at the farmer's location, so that farmers can increase their coconut sap productivity. Assistance from the private sector in Hargotirto and Hargowilis villages can be a good example of sustainable community empowerment. Economically, community income from coconut sugar is higher than local market prices, as it follows organic standards, and all coconut sugar products are exported, which guarantees sustainability as market demand continues to increase. The coconut sugar price, in 2022, was IDR21K/kg, then in 2024 it became IDR26.5K/kg which means an increase in income from coconut sugar 26,500 – 21,000 = 5,500. Therefore, 5500 ÷ 21,000 × 100% = 26% increase in income. There are several treatments that farmers can do to increase their coconut sap productivity, namely technical treatment [giving dolomite to increase soil pH, making organic fertiliser, making *jogangan/rorak* (water trap) and making terracing using A frames], non-technical treatment (assistance, making leaflets, and banner stands) and also for sustainability through market access and certification. Technical treatment has been carried out on mangosteen, cocoa, and several other plants, including coconut (because it requires permission from the certification body for the certification process), and the results are quite good. Mangosteen and cocoa, which previously never bore fruit, now do. By implementing technical and non-technical treatments that farmers can carry out themselves using locally available materials, we can improve soil fertility. Increased soil fertility will also increase productivity. Increased productivity will automatically increase farmers' economic income. From this research, we can see a clear example of private-sector support for community empowerment. For further research, there is an opportunity to explore how to increase the productivity of the organic coconut sap method.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

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Appendix



(a)



(b)



(c)



(d)

Figure 6: (a) Meet the village leader and some subvillage leaders, (b) interview session, and (c) and (d) women cooking the coconut sap