BUILDING RESILIENT, INCLUSIVE, FORESTED JURISDICTIONS IN INDONESIA

Bone Bolango District

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1 General overview

1.1 Profiles

Bone Bolango is a district located in Gorontalo Province, on the island of Sulawesi. It is a relatively young district, established in 2003 based on Law no 6/2003. Previously, it was part of the Gorontalo District when Gorontalo Province was established in 2000.

1.1.1 Population

The population of Bone Bolango District in 2020 was 162,778 people, with nearly 15% of them residing in Kabila Sub-District. Meanwhile, South Bulango Sub-District has the highest population density, which is 1,917 people per km^2. Both sub-districts are located in the southwest of Bone Bolango and share their border with Gorontalo City, which is the capital of Gorontalo Province, where 17% of the total population in the province reside, although it holds only 0.7% of the total area.

Figure 1. *The administrative map of Bone Bolango*

1.1.2 Main sectors and livelihoods

According to the District's Statistics Bureau (*BPS Kab. Bone Bolango*) , agriculture, forestry and fishing are the top sectors contributing to the District's Gross Domestic Product (GDP), with a total of IDR 1,677.44 billion (around USD 118 million), or 36% of the overall GDP, in 2020. The principle agricultural products include rice, corn, fruits, vegetables and plantation crops. Bone Bolango District has a large area of agricultural land, covering 19% of the district's total area and 75% of all areas designated for

non-forest use, especially in the southwest. Some commodities that appear to be the most widely grown commodities according to the spatial analysis of land use are corn, rice and coconut, which are managed independently by local communities with support from the district, provincial and central governments. The support provided includes assistance with production equipment, technical guidance, and seeds.

In the Bone Bolango District, about 26% of the workforce is employed in the manufacturing and service industries, with the remaining 74% in the agriculture, plantation, forestry, hunting, and fishing sectors. Nevertheless, the manufacturing and service industries contributed around 36% of Bone Bolango District's overall GRDP in 2020, making this sector crucial for future development. This sector increased between 5-7 percent from 2017 to 2019 but declined to -0.8 percent in 2020, according to its growth.

1.1.3 Geographic profile

The geographic location of Bone Bolango District spans across 188,566 hectares according to the spatial data collected from the Geospatial Information Agency (*Badan Informasi Geospasial*, or BIG)[1], with elevation levels varying from 0 masl to about 2,000 masl dominated with areas (53% of total area) with an altitude between 0 and 500 masl. Thirty-eight percent of the district's area is at an elevation between 500-1000 masl, with the remaining 14% at an altitude above 1000 masl. Most settlement areas and agricultural activities are located in an area with an altitude of 0-100 meters above sea level (approximately 16,986 hectares or 9% of the total area of Bone Bolango District).

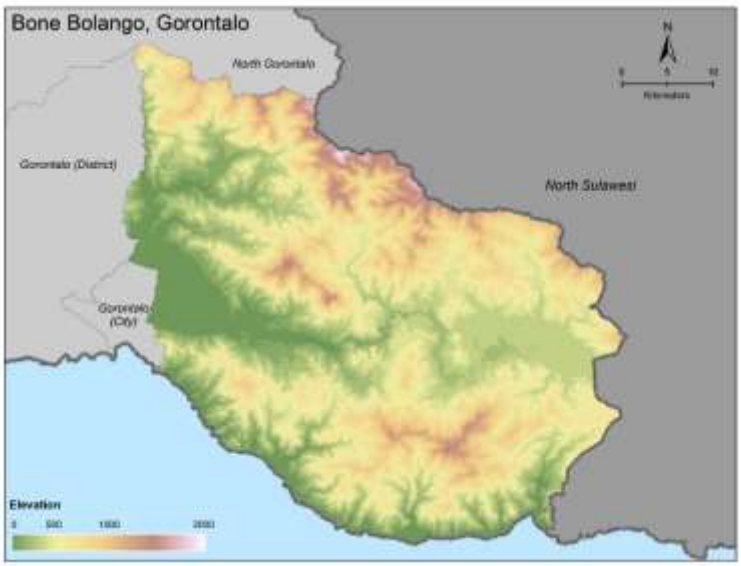

Figure 2. *The elevation map of Bone Bolango*

[1] The Home Affairs Ministerial Regulation No. 137/2017 states that the total area of Bone Bolango District is 191,544 hectares. Due to the relatively modest difference and the use of this spatial data for further spatial analyses, the spatial data will be used in this study.

1.1.4 Policies, commitments, sustainability strategies

1.1.4.1 Conservation District

Due to the high forest cover, the District Government of Bone Bolango has prioritized protecting its forests, which was realized through the district's commitment to make Bone Bolango a conservation district. This commitment was verbally expressed by the Head of District in 2017, when opening the workshop for the development of the Maleo Senkawor (*Macrocephalon maleo*) Conservation Strategic and Action Plan 2018-2027. One of the main reasons for making Bone Bolango a conservation district is to save conservation areas that became the habitat of endemic animal flora and fauna, one of which is the maleo. The Head of Bone Bolango District has mentioned its commitment to promote Bone Bolango District as a conservation district on several other occasions until recently, although such commitment has not been formalized into a regulation. The term conservation district occurred in the medium-term development plan (*Rencana Pembangunan Jangka Menengah* / RPJMD), which explained the strategic issues covered in this commitment without any specific plan or targets

1.1.4.2 Forest and Peatland Protection

During LTKL's (Lingkar Temu Kabupaten Lestari) General Assembly in July 2021, LTKL member districts, including Bone Bolango, agreed to commit to protecting their forest and peatland areas by 2030, as outlined in the Declaration of the Vision of Sustainable Districts. More specifically, the districts made the commitment to work together with stakeholders across sectors to protect at least 50% of the total forest, peat and other critical ecosystems within the jurisdictions through an approach that ensures at least 1 million families living in and/or around important ecosystems within the districts can increase their wellbeing. Several means to achieve this target include attracting sustainable investments into the districts, providing new job opportunities and avoiding disasters and climate crisis.

1.2 Forest and land use

According to the Environment and Forestry Ministerial Regulation No. 734/2014, which defines the forest and non-forest zone, the area available for non-forest use, including agricultural activities and urban development, is only 26% of the total area of Bone Bolango District. The rest of the area is designated for forest-related land use, including production forest (10%), protection forest (8%) and national park (56%). These figures are also consistent with the district's latest spatial planning for the 2021-2041 period (Bone Bolango District Regulation No. 5/2021).

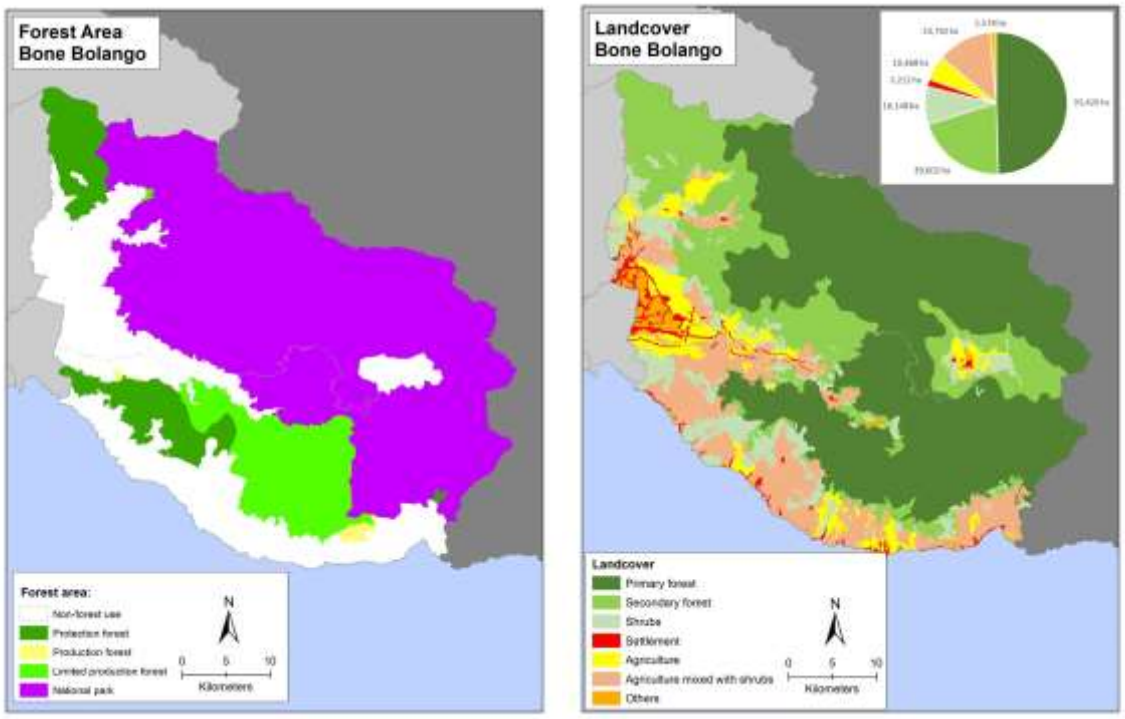

Figure 3. *Maps showing forest and land cover in Bone Bolango in 2019. Source: Ministry of Environment and Forestry*

1.3 Agriculture

1.3.1 Overview

Based on the Districts' Statistics Bureau (*BPS Kab. Bone Bolango*), the agricultural commodities are divided into several types, which are fruit, vegetable, plantation and food crops. In 2020, bananas were the top fruit produced in the district, followed by papaya, mango and durian. For seasonal vegetable crops, chilis are in first place with 1,450 tons, higher than tomatoes, water spinach and spinach. The three top plantation crops produced in this district in the same year were coconut, cacao and coffee. For staple food crops, rice and corn are the most widely grown crops. Based on the Districts' Statistics

Bureau (*BPS Kab. Bone Bolango*), 27,568 tons of rice and 12,051 tons of corn were produced in 2015 from 4,411 hectares and 2,523 hectares of rice and corn fields in 2015.

Table 1. *Annual production of some top agricultural commodities*

Type of crops	No	Commodity	Annual Production (tons)
Fruit	1	Banana	27,052
	2	Papaya	10,601
	3	Mango	2,728
	4	Durian	2,320
Vegetable	1	Chili	1,458
	2	Tomato	148
	3	Water spinach	84
	4	Spinach	15
Plantation	1	Coconut	2,301
	2	Cacao	96
	3	Coffee	33
Food crop	1	Rice	27,568
	2	Corn	12,051

The District Government of Bone Bolango has selected two commodities as the main commodities to promote: coffee and palm sugar. The two commodities were selected inconsideration of their unique historical values, qualities, climate and soil suitability, forest conservation functions and expansion potential. According to the Government of Bone Bolango District, both coffee and sugar palm trees have been cultivated in the District for a long period of time, with coffee particularly grown in Pinogu Sub-District having strong historical origin. Claims that the consumption of coffee and palm sugar produced in the District have health benefits have been used in the promotion of the commodities in the domestic and international markets[2]. The promotion of these two commodities aims to increase the local economy through forest-friendly commodity production that is in line with the Conservation District agenda, as both coffee and sugar palm trees possess forest conservation functions by decreasing the likelihood of soil erosion, while also providing economic benefits to local communities.

In 2014, the District government issued a district-level regulation on protection of land for sustainable food production (*Perlindungan Lahan Pertanian Pangan Berkelanjutan*), which designated at least 2,046 hectares (6% of existing agricultural land) of land for sustainable food agriculture. The main objective of this regulation is to protect and develop agricultural land to fulfill the regional staple food needs. In this context, the government will not only develop and protect the land but also enhance the farmers skill and knowledge to optimize the food production.

[2] https://gorontalo.antaranews.com/berita/35218/bone-bolango-fokus-kembangkan-gula-aren-kopi-pinogu

1.3.2 Focus Commodities

Three commodities —coffee, palm sugar and corn—that are produced in large quantities and contribute significantly to the economy of the district were chosen as the focus for the study. These three commodities also have a link to the district's forest cover changes. As focus commodities, these four commodities to further explore the profitability of their production, the impact they have on the extent of forest cover, and the challenges faced by farmers who want to increase their profits without clearing the forest.

1.3.2.1 Coffee

In Gorontalo Province, the largest coffee plantation is located in the Bone Bolango District. Around 33% (513 hectares) of the province's coffee plantation is located in Bone Bolango[3]. Despite having the greatest coffee plantation area in the province, Bone Bolango District's coffee production is still less than those of North Gorontalo and Gorontalo. This is a result of the district's coffee trees, many of which are still immature and have been damaged. A total of 22% and 46% of the total area of coffee plantations are, respectively, in immature and damaged conditions. The productivity of mature coffee fields at 205 kg/ha is less than that of the other two districts, which is 286 kg/ha and 232 kg/ha[4] as shown in Table 2.

Table 2. *Comparison of coffee plantation area and production at the district level in Gorontalo Province in 2018*

District	Planted area (ha)				Production (ton)	Yield (kg/ha)	Farmers
	Immature	Mature	Damaged	Total			
Boalemo	10	165	144	319	24	145	405
Pohuwato		67	2	69	5	75	102
Bone Bolango	113	161	239	513	33	205	1281
Gorontalo Utara	5	213	164	382	61	286	470
Gorontalo	8	181	79	286	42	232	304
Total	136	787	628	1,551	165		2,562

The data indicate that the production and planted area of coffee both fell by 10 and 6 percent, respectively, between 2017 and 2020 (Figure 4). However, according to several officials from the District's Agriculture Agency, this decline was caused by different data collection methodologies between the 2017-2018 data and 2019-2020 data. The former estimated all the coffee plantations, while the latter calculated only the productive trees.

[3] Central Statistics Bureau - Gorontalo Province / BPS Provinsi Gorontalo. 2021. Gorontalo Province in Figures 2021.
[4] Directorate General of Plantation. 2020. Plantation Crop Statistics of Indonesia 2018 - 2020: Coffee

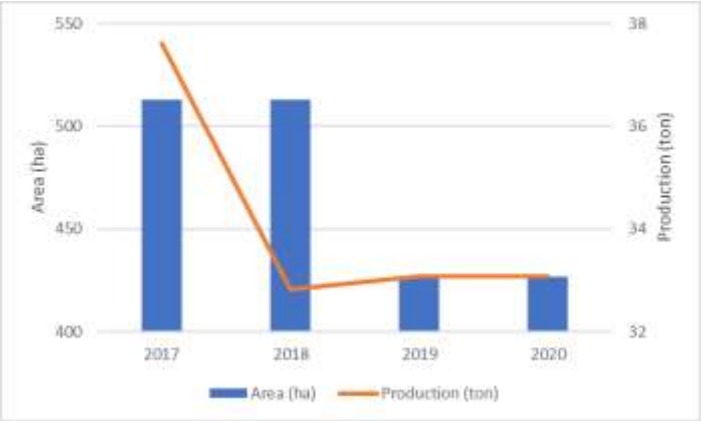

Figure 4. *Total area and production of coffee in Bone Bolango District 2017-2020. Despite a minor rise in productivity from 73 kg/ha in 2017 to 77 kg/ha in 2020, all planted land is included in this productivity calculation due to a lack of data on the state of the planted area.*
(Source: Central Statistics Bureau - Bone Bolango District / BPS Kab. Bone Bolango)

1.3.2.1.1 Pinogu

Pinogu is a sub-district in Bone Bolango District that is enclaved within the Bogani Nani Wartabone National Park. In Pinogu Subdistrict, all settlements, agricultural areas, and plantations are situated in a non-forest use area. It has an area of 40,596 ha and consists of 5 villages in which around 2,040 people reside: Pinogu Induk, Bangiyo, Dataran Hijau, Tilongbilia and Pinogu Permai. As access to national parks is restricted to discourage illegal clearing, the access to and from the sub-district is very low. The nearest village to Pinogu sub-district is 40 kilometers away; accessing the sub-district takes around 10 hours of walking or 5 hours by motorcycle (subject to weather conditions) The sub-district is located in the Tilongkabila Mountains at an altitude of 247 to 1,600 meters above sea level. Most of the coffee plantations are located within an altitude of 400 to 600 meters.

Figure 5. *The settlement area in Pinogu sub-district from satellite image. Administratively, this settlement area is split into five villages.*

Pinogu is known for its organically produced agricultural products, including rice, coffee, cacao, rice and candlenut. Among these, coffee is the main source of income for most of the households in the sub-district[5]. Coffee in Pinogu has been produced since 1879 when coffee trees were planted by the *Vereenigde Oostindische Compagnie* (VOC), a Dutch trading company, and have since remained productive. According to the District Agency of Agriculture and Livestock, there are 524 coffee farmers in Pinogu. The varieties of coffee trees in the sub-district are dominated by *robusta* and *liberica*[6,7], which were the varieties planted by the VOC. Pinogu coffee is said to be very low in caffeine (around 0.6%), which could benefit from the growing global demand for low-caffeine coffee that has been observed in the last few years. The taste of Pinogu coffee has also been tested by the Indonesian Coffee and Cacao Research Institute (*Pusat Penelitian Kopi dan Kakao* or PUSLITKOKA) and received a score of 80.75-81.75, which is indicative of excellence[8].

According to Humola et al. (2021)[9], coffee plantations in Pinogu Sub-district are spread across all of its 5 villages. Some coffee plantations are dominated by dystropept soils (82%), tropaquept soils (9.4%) and tropudults (8.6%), which are particularly suitable for growing coffee plants. Most of these plantations are on sloped lands, with steep grades between 25-40%, and some are on steeper lands with steep grades of more than 40%, which are prone to erosion[10].

Pinogu coffee has several competitive selling points, mainly because it is produced organically without using chemical fertilizers and pesticides and it has obtained the certification for geographic indication[11]. Such certification indicates that the product possesses certain qualities and characteristics, is made according to traditional methods, or has a good reputation due to its geographical origin. This certification could also help increase the quality of the products, as fellow rights holder organizations would be motivated to set specific production and processing standards across all stakeholders involved along the supply chains of the products in order to create, provide, and strengthen the products' images and reputations. Other potential positive impacts of such certification include an increase in production and market price, broader market, avoidance of fraudulent competition practices, an increase in consumer confidence and subsequently preference and fostering of local producers. This certification could also act as a means to promote the areas in which the products are produced, and therefore promote other industries that could bring about benefits to the areas, such as agro-tourism. The certification was obtained for Pinogu's *robusta* variety in 2017 after a three-year registration process, which was pursued by the Society for Geographic Indications of Pinogu Robusta Coffee Bone Bolango (*Masyarakat Indikasi Geografis - Kopi Robusta Pinogu Bone Bolango* or MIG-KRPBB).

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[5] Ahmad, I., & Paserangi, H. 2018. Initiating the Community Economic Improvement through Intellectual Property Registration of "Robusta Pinogu Coffee". Hasanuddin Law Review, 4(1), 103-112.

[6] Sancayaningsih, R.P., et al. 2016. Community empowerment program in Pinogu Subdistrict, Bone Bolango Regency, Gorontalo Province, Indonesia: Concerning the unique biodiversity conservation. Indonesian Journal of Community Engagement, 1(2), 183-193.

[7] Ahmad & Paserangi. 2018.

[8] Mooduto, W. I. S., et al. 2021. Analysis of Pinogu Coffee Supply Chain in Bone Bolango. Jurnal Pascasarjana, 6(2).

[9] Humola, Y. 2021. Identifikasi Perkebunan Kopi Menggunakan ArcGIS di Kecamatan Pinogu Kabupaten Bone Bolango. Jurnal Teknologi Pertanian Gorontalo (JTPG), 6(1), 1-6.

[10] Humola, Y. 2021.

[11] Ahmad & Paserangi. 2018.

Coffee is also produced in areas outside of Pinogu Sub-District, although to a very limited extent. There are small-scale coffee plantations located in Ilomata and Suka Makmur Village. Coffee plantations in the two villages did not develop because farmers preferred other commodities, including palm sugar and vegetable crops.

1.3.2.2 Palm Sugar

Another strategic commodity currently promoted by Bone Bolango District is palm sugar. Around 93% of palm sugar in Gorontalo Province is produced in this district[12]. Based on the information from the District Agency of Agriculture and Livestock, the total planted area for sugar palm in the district is 506 ha and the total harvested area is 298 ha, with an annual productivity rate of around 1,987 kilograms per hectare. The total production of palm sugar in 2018 was 590 tons. Palm sugar is still produced using traditional methods, using traditional stoves run on firewood and coconut shells as molds to produce brick palm sugar.

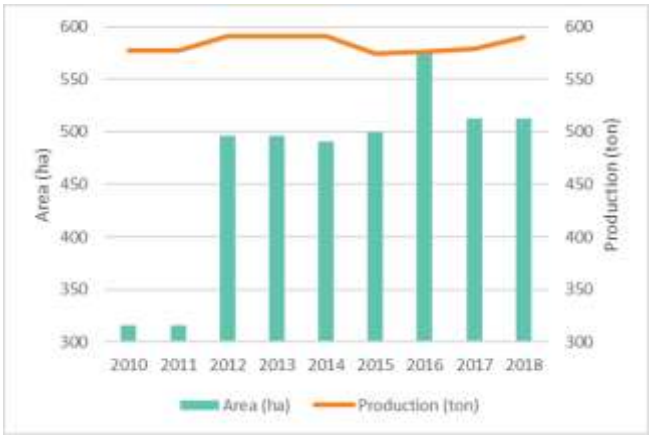

Figure 6. *Total area and production of sugar palm in Bone Bolango District 2010-2017. Source: Central Statistics Bureau - Bone Bolango District / BPS Kab. Bone Bolango*

1.3.2.3 Corn

Among all crops planted in Bone Bolango, corn is considered the main crop, although it comprises only 2.2% of all corn production in the province. Despite often being considered as a staple food crop for human consumption, the majority of corn planted in Bone Bolango is intended for animal feed production. Corn is commonly produced by members of local communities, totaling 57,891 tons in 2020 with a total planted area of 9,463 ha and a total harvested area of 12,023 ha (District Agency of Agriculture and Livestock). The most commonly planted corn varieties are hybrids (e.g., NK212) which have a large market, high resistance towards plant diseases and a high level of productivity of more than 6 tons per hectare[13]. In addition to being consumed, hybrid corn is also employed as a raw material in industry. Large amounts of hybrid corn are farmed for a variety of purposes, including animal feed

[12] https://gorontalo.bps.go.id/dynamictable/2017/10/05/153/produksi-tanaman-aren-menurut-kabupaten-kota-di-provinsi-gorontalo-2010-2017.html
[13] https://infopublik.id/galeri/foto/detail/117374

(forage and cobs), oil production (from seeds), flour production (cornstarch or flour), and industrial raw materials (from seed flour and cob flour). In the district, corn is regarded as the key product in food crop sector[14].

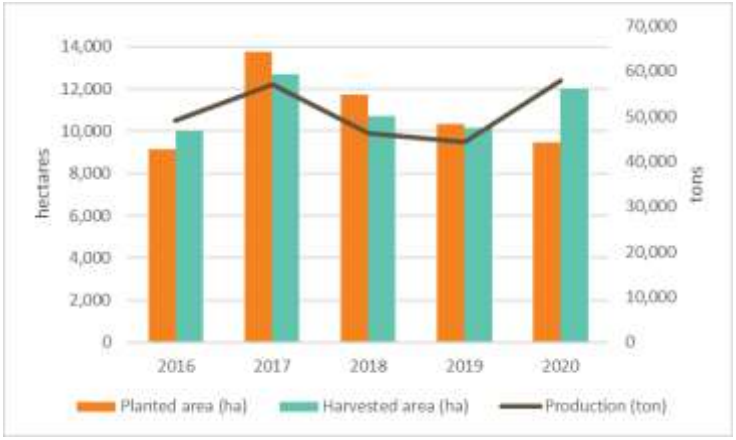

Figure 7. *Total Planted and harvested area and production of corn in Bone Bolango District 2016-2020. Source: District Agency of Agriculture and Livestock / Dinas Pertanian dan Peternakan Kab. Bone Bolango*

There are a number of factors that drive local communities to produce corn. The minimum and maximum retail prices of corn are regulated by the Ministry of Trading to ensure the availability of corn–among many other staple food items–and price stability. These prices are set in consideration of a number of factors, such as profits and costs associated with raw materials, labor, land, logistics and distribution and other specific characteristics. If the price of corn falls below the set minimum price, the Ministry will appoint BULOG (Indonesian Bureau of Logistics), a state-owned company, to purchase corn from farmers at the set minimum price. Based on the Regulation of the Ministry of Trading no. 7/2020, the minimum purchase prices directly from farmers range between IDR 2,500 to 3,150 per kilogram, depending on the water content. Such security in the prices, and therefore the profits made by corn farmers, has potentially encouraged farmers to produce corn. Corn cultivation is also deemed relatively simple by local communities and requires minimal tending and maintenance.

Both local and national governments have provided assistance to boost corn production. Such assistance includes the provision of seeds for the hybrid variety, training, tools for cultivation and processing harvested corn, such as UV dryers.

1.3.2.4 Other commodities

Aside from coffee, palm sugar and corn, other top commodities in Bone Bolango District, selected based on planted areas and production, include coconut, cocoa and rice. The planted areas and production of these commodities are presented in Table 3.

[14] https://infopublik.id/read/165903/bone-bolango-miliki-ragam-komoditas-unggulan-sektoral.html

Table 3. *Planted area and production of coconut and cocoa in Bone Bolango District in 2019 and 2020*

Crops	Planted area (ha)		Production (ton)	
	2019	2020	2019	2020
Coconut	6,446.76	6,631.01	2,093.19	2,301.08
Cocoa	2,276.70	2,276.70	115.07	96.11
Rice	3,455.18	5,164.28	16,995.86	25,490.29

Coconut is widely produced in the district, with high demands for its derivative products. One of the most commonly produced derivative products of coconut is coconut oil as it is commonly used locally for cooking. Coconut is also used as a raw ingredient by coconut milk factories in addition to being sold as granules. There are traders in Bone Bolango District that purchase processed white copra and ship it to manufacturers in Surabaya City for export to nations in Europe. However, the processing of coconut is still done in a traditional manner, which limits its efficiency and yield.

In Gorontalo Province, cocoa production in Bone Bolango District is the lowest. However, the price of cocoa beans is relatively high, and the constant demand from traders creates opportunities on the market that motivate farmers to keep growing cocoa plants. Opportunities for marketing in places outside of the region are good enough, like Central Sulawesi.

Rice production in Bone Bolango District is one of the lowest in Gorontalo Province when compared to other cities or districts, only higher than Gorontalo City with production in 2020 reaching 25,490 tons from 5,164 hectares of rice fields. Suwawa, Tilongkabila, Kabila, South Bulango, and East Bulango are five sub-districts that are major rice producing areas in the district[15]. The local market's traders and retailers are the target market for the rice selling in this district. However, there are also some opportunities to market rice outside the region, such as in North Sulawesi[16].

2 Land use change analysis

2.1 Identified drivers of deforestation

The existing land cover data shows that 70% (132,428 hectares) of the district is still covered by forests (50% primary, 20% secondary). In 1996, more than 81% of the land cover was forest. Most of the agricultural expansion and accompanying deforestation occurred between 1996 and 2006, when agricultural land and rice fields increased by 32% and 69%, respectively. This was particularly true after Gorontalo Province was established in 2001 and its first governor implemented an agricultural development program, focusing on corn. During this period, there were also occurrences of major

[15] Indrianti, M. A., Pomalingo, N., & Jamil, M. H. (2016). Pengembangan Komoditas Unggulan Tanaman Pangan di Kabupaten Bone Bolango. Jurnal Sains dan Teknologi, 16(3), 203-209.

[16] Imran, S., Si, S. P. M., Nurdin, S. P., & Indriani, R. Kajian Nilai Tambah Produk dan Skema Peluang Pasar Program READSI TAHUN 2021.

deforestation and forest degradation. About 22% or 28,181 hectares of the primary forest disappeared, 95% or 26,755 hectares degraded into the secondary forest and 5% or 1,426 hectares were converted to other land uses.

Table 4. *Land cover change from 1996 to 2019*

Landcover	Area (ha)			
	1996	2006	2016	2019
Primary dryland forest	124,680	96,499	94,735	93,426
Secondary dryland forest	28,717	36,516	36,567	39,002
Shrubs	6,972	17,695	16,773	16,148
Plantation	63	556	497	141
Settlements	700	442	2,914	3,212
Bareland	17	202	7	116
Agriculture	7,012	10,009	10,201	10,468
Agriculture mixed with shrubs	16,928	22,454	24,220	23,732
Rice fields	2,477	4,193	2,524	2,181
Mining			127	140

In 2019, about 49% or 9,498 hectares of land deforested between 1996 and 2006 was used for agriculture and plantations. The other 48% was covered by shrubs, while the remaining was settlement areas. Based on the results of interviews with the stakeholders from the local government, most of the deforestation during this period was caused by forest encroachments and illegal logging.

More recently, deforestation that occurred in the district was caused by small-scale farming, mostly corn cultivation. In Bone Bolango, corn has become the most important raw material for animal feed and also as daily food. Corn is relatively easy to cultivate by small-scale farmers. Some corn fields are also located on steep slopes of more than 45% which should be a protected area for landslide prevention.

2.2 Potential future deforestation

2.2.1 Corn farming - increased demand

Corn production in Bone Bolango District is expected to expand as a result of increased market demand and the district government's focus on developing the district's corn production as part of a province that makes corn the major commodity to boost the regional economy. The main challenge confronting Bone Bolango District is the limited availability of agricultural land, since 70% of the district's area is already designated to conservation and protected areas. According to the 2019 land cover data and the most recent district spatial plan, there were 3,556 ha of forested land within the area allocated for non-forest use, which likely will be converted in the near future for agriculture or settlement area expansion. Another risk is the expansion of agriculture in areas designated as protected and conservation areas, particularly those that are close to settlement areas.

2.2.2 Coffee and palm sugar

Being the two focus commodities that are promoted by the district government, which can drive up future demand, there need to be adequate safeguards that can ensure that the production of the two commodities can be increased to meet the target demand without compromising forests. Such measures could include intensification of production in already planted areas, supported by adequate capacity building and technical assistance that introduce newer, more effective and sustainable farming practices.

2.2.3 Large scale mining

Mineral extraction is currently not an important sector for the District's GDP; smallholders carry out mining activities over a 140-ha area in the district. Having a vast area enriched with mineral resources, a number of small- and large-scale mining companies are tapping into the potential for extraction in the District. One notable mining company that is in the preparation stage of operation in the District is PT. Gorontalo Minerals (GM), a large-scale gold mining company that obtained a production operation permit from the Ministry of Energy and Mineral Resources in 2019 for copper and gold mines on a total area of 24,995 ha. However, a majority of this area was classified as a forest area, with 17,798 ha located in protected and production forests, and the remaining 7,197 hectares in an area classified as "land for other purposes" (*Area Penggunaan Lain* or APL). The company's concession area is also located close to the Bogani Nani Wartabone National Park, the largest land national park in Sulawesi.

Many members of local communities and environmental organizations have expressed opposition to the re-designation of forests into the concession areas due to the threat of deforestation they allege the re-designation will cause. Many have also expressed fears that the company's operations will cause further environmental degradation and disasters, such as further deforestation to the nearby national park due to the opening of access for the company's operational activities as well as flooding due to forest clearing.

Some of the potential major impacts of this mining are biodiversity loss and flooding. Biodiversity within the GM concession will be affected once the company operates their open pit mining activities because the company is located next to the national park with high biodiversity and important habitat for species. From the analysis document regarding the company's environmental impact (AMDAL), there are hundreds of flora and fauna species that are threatened if gold mining operations begin. The loss of existing forests will also exacerbate flooding in settlement areas downstream. In 2020, flash floods and landslides took the lives of people and property in the Bone Raya Sub-District caused by extremely high rainfall for three consecutive days at the beginning of the rainy season. It is feared that a bigger disaster will come to the village with mining operations in the future.

2.3 Impacts of deforestation

2.3.1 Flooding and landslides

For at least the last three consecutive years, Bone Bolango District has experienced heavy flooding, especially in settlement areas. Several sub-districts that are frequently flooded during the rainy season include Bulango Utara, Bulango Selatan, Kabila, Bone Raya and Bone Sub-Districts. The occurrence of floods during high intensity rains shows the importance of maintaining the forest cover in the upstream area which is currently still in good condition.

Figure 8. *Bone river in Suwawa Timur sub-district*

In addition to flooding, landslides also often occur during the rainy season. In 2020, there was a landslide that was quite severe in Bone Raya Sub-District. To mitigate landslides, current forest cover needs to be maintained. In addition, law enforcement is needed to prevent communities from growing corn in prohibited areas, such as in areas with more than 45% slope, replacing it with crops that can be used for soil conservation.

2.3.2 Biodiversity loss

With around 50% of its area covered by primary forest, Bone Bolango District also has high biodiversity. Within the Bogani Nani Wartabone National Park alone, there are 400 types of trees, 24 species of mammals, 11 species of reptiles, two species of amphibians and 64 species of bird. Some of the species are endemic to the Island of Sulawesi, including *Macrocephalon maleo* or commonly known as maleo (a large, chicken-like bird species), which is considered to be critically endangered according to the International Union for Conservation of Nature (IUCN).

According to the Bogani Nani Wartabone National Park management, the rich biodiversity has attracted many tourists, especially bird-watchers, to the national park, with maleo being the most

commonly sought-after. Forest clearing and degradation may cause habitat loss for this and many other endemic species. Biodiversity loss also reduces income for communities living around the national park who rely on ecotourism as their source of income, such as lodging providers.

2.4 Report focus commodities and forests/land use

Two of the three focus commodities, which are coffee and palm sugar, are commodities promoted by the Bone Bolango District government. Coffee and palm sugar cultivation may be considered to be sustainable as both are considered to be native forest tree species. However, there is potential for land expansion for coffee and sugar palm plantations when the government succeeds in attracting investors or buyers. This could potentially lead to deforestation, as both of these plants can be cultivated in areas that are currently still forested.

On the other hand, corn, which is not promoted by the local government, is still a favorite for local communities. The relatively easy cultivation, the regulated pricing system and the increasing demand for corn as animal feed ingredients are the three main factors for the potential expansion of corn fields. Although there is not too much land available for corn expansion because of the limitation of land allocated for agriculture purposes, it is still necessary to pay attention to potential corn expansion on land with steep slopes, which has the potential to cause landslides in the future.

3 Value chains of focus commodities

3.1 Coffee

The primary actors of the Pinogu coffee supply chain are farmers, traders, local retailers (such as traditional and modern markets), domestic and international buyers, agroindustries (small and medium-sized enterprises), and consumers. The majority of the coffee trees in Pinogu are *robusta* varieties that have been planted for many years, while others are *liberica* varieties that date back to the Dutch colonial era of the 19th century. Within the cultivation phase, coffee trees are fertilized using organic fertilizers, as agricultural practices in the sub-district are maintained to be organic. Farmers also perform other cultivation activities like weeding, pruning, and upkeep of fences that protect coffee trees from cattle. Pinogu coffee is harvested two times every year. Farmers must determine which coffee cherries are ready for harvest and must set up sacks and containers for sorting coffee cherries before they can begin harvesting. Once harvested, coffee cherries are sorted, graded and dried for two to five days, depending on the amount of coffee harvested. Upon drying, the coffee beans are hulled. Some farmers then sell the hulled coffee as green beans or roast them using a clay-based wok to retain the distinguished coffee aroma. Depending on the intended end products, the roasted coffee beans are sold as beans or ground to be sold as ground coffee. The processed coffee is then packaged for distribution. Due to the limited supply, Pinogu coffee is mostly sold within the province and the domestic market despite demands coming from the international market, particularly the Netherlands.

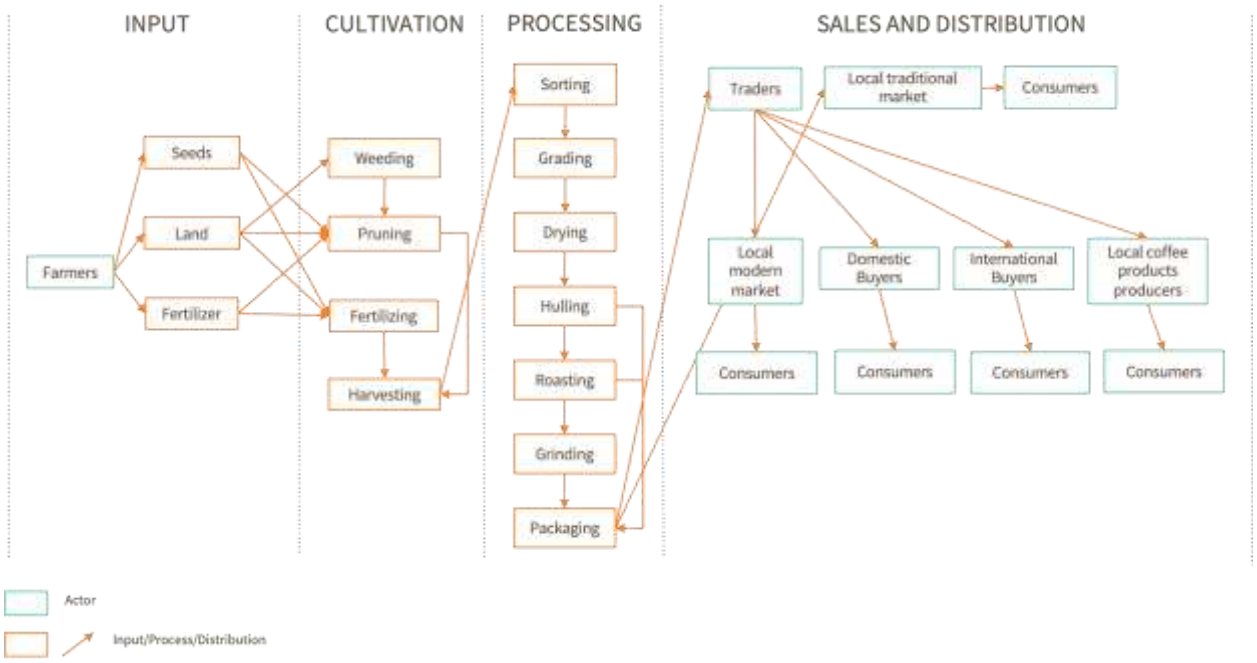

Figure 9. *Flow chart of actors, inputs and processes of coffee production in Bone Bolango District*

Based on a series of interviews with coffee farmers in Bone Bolango District, the types of coffee products sold by farmers include green beans, roasted beans and ground coffee. The decision to sell the different products depends on several factors, such as buyers' demands, ability to meet the capacity to conduct further processing and stock availability. In addition, to a very limited extent, local communities produce bottled iced coffee using coffee produced in Bone Bolango District, with the support from the District Agency for Trade and Industry. The direct buyers of the principal three products (green beans, roasted beans and ground coffee) include traders, local traditional markets, cafes and end consumers. Depending on the types of products purchased, these buyers will either directly resell the products or conduct further processing (as for green beans) and then resell to the next buyers.

Figure 10. *Pinogu coffee at one of the local coffee shops in Bone Bolango District*

Between producers and markets, communication occurs via bidirectional information flow. Farmers share information related to the produce, such as the grades, roasting methods, prices by grades, quality and weight as well as the sale transaction mechanism[17]. Farmers market their goods based on consumer demand. Ground coffee makes up the majority of the coffee goods sold, with roasted coffee beans making up the remainder. The packaging's weight is also determined by consumer demand. Coffee beans are often packaged at a weight between 200 grams and 1 kilogram, whereas ground coffee is typically between 100 grams and 200 grams.

3.2 Palm Sugar

The production of palm sugar is mostly done using traditional methods and materials, where farmers harvest the sap of sugar palm trees and process it by boiling it for 4-5 hours using traditional stoves, mold it using coconut shells to produce brick palm sugar, or boil it for a much longer time to produce granulated sugar. The average daily production of palm sugar is around 5 kilograms per producer. The final products are mostly sold by farmers to traders and, to a more limited extent, directly to local traditional and modern markets, including minimarts. Similar to Pinogu coffee, the district government of Bone Bolango has made a formal agreement with modern convenience stores to carry palm sugar produced in the district in order to reach a wider market[18]. Demands for palm sugar vary along the year, with higher demands observed before and during the month of *Ramadhan* as it is used as an ingredient for traditional snacks typically consumed during that time of the year. During Ramadan, the demand for palm sugar could reach 11 tons.

The palm sugar production is centralized in Bolango Ulu Sub-District, with 237 of people living in the sub-district identified as sugar palm farmers. To support the production of palm sugar in the sub-district, the district government has recently built production centers to help the farmers in producing palm sugar more efficiently. These production centers can help the farmers with processing, packaging, and marketing palm sugar products, and the establishment of these production centers had cost IDR1.2 billion[19]. However, according to the District Agency for Trade and Industry, most farmers still prefer to

[17] Mooduto, W. I. S., et al. 2021. Analysis of Pinogu Coffee Supply Chain in Bone Bolango. Jurnal Pascasarjana, 6(2).
[18] https://sulut.inews.id/berita/ritel-modern-jualan-kopi-pinogu-dan-gula-aren-bulango-ulu-dari-umkm-bone-bolango
[19] https://gorontalo.antaranews.com/berita/35218/bone-bolango-fokus-kembangkan-gula-aren-kopi-pinogu

process the harvested palm sugar traditionally at home. It is easier, more convenient and does not require farmers to travel to the processing centers. There is a minimum amount of raw material (i.e., sap) required to use the machines at the processing centers (the machines cannot process only a small amount of sap), thus farmers have less flexibility when compared with employing traditional methods. Traditional methods for processing palm sugar have also been observed to be in use by the majority of farmers living outside of Bolango Ulu Sub-District. There are several variations of actor flows, which are: (1) Farmers – consumers; (2) Farmers – traders– retailers – consumers; (3) Farmers – traders– large retailers outside the district – consumers.

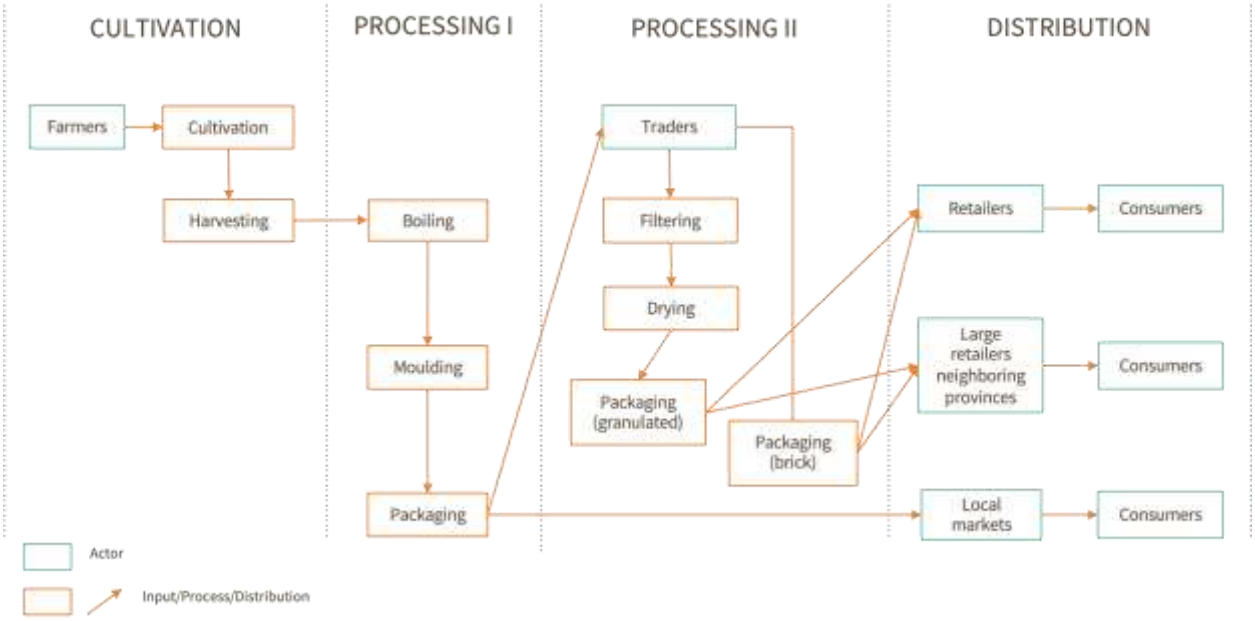

Figure 11. *Flow chart of actors and processes of palm sugar production in Bone Bolango District*

3.3 Corn

Corn is one of the most cultivated crops in Bone Bolango District, as it is considered a lucrative crop locally. Many farmers formerly planting other crops, such as coffee, have substituted their trees with corn plants[20] Despite being classified as a staple crop, corn in the District is mainly produced for animal feed. The varieties for both purposes are also different: the most common corn varieties planted and produced into animal feed are the hybrid varieties, such as NK and BISI, while the variety produced for human consumption is sweet corn. The cultivation practices for the different corn varieties are similar, but the post-harvest processes are different as corn for animal feed is sold as dried corn kernels, whereas corn for human consumption is sold undried on the cobs.

[20] Murtisari, A. (2015). Pendapatan, Sumber dan Distribusi Pendapatan Rumah Tangga Petani Jagung di Kabupaten Bone Bolango. Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah, 2(3), 129-134.

Typically, farmers themselves own the land they use for corn farming or are employed by landowners to cultivate corn. In the latter arrangement, the profit-sharing mechanism usually includes entitlement of a portion of the harvest by farmers, which they can sell, while the rest is given to the landowners. Landowners also often supply or provide subsidies to farmers to procure agricultural inputs, such as fertilizers and herbicides. Corn cultivation activities include fertilizing twice a month and clearing the land using a hand tractor or applying pesticides when weeds begin to appear. This activity is usually carried out by members of the farmer's family, or also by paid workers. All inputs are bought and prepared by the farmers.

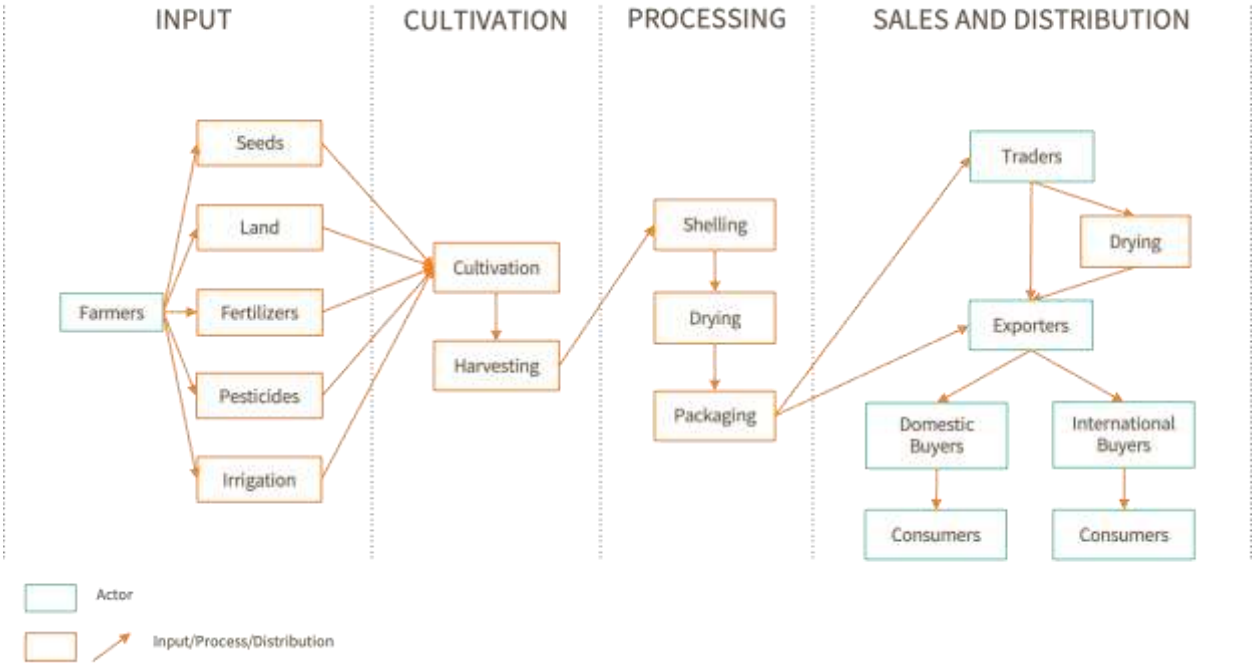

Figure 12. *Flow chart of actors, inputs and processes of corn production in Bone Bolango District*

Corn is typically harvested twice every year. Upon harvest, farmers shell and dry the kernels to reduce the water content in the produce. The market prices for corn kernels vary according to the water content; corn with higher water content is priced lower than that with lower water content. Therefore, the drying process is a crucial value-adding process. When drying equipment (e.g. ovens) is not available, farmers and processors rely on the sun-drying method, which relies heavily on optimal weather conditions. The dried corn is then sold to local exporters in Gorontalo, either directly or through local traders that may conduct further drying to further decrease the water content and increase the price of the corn. These exporters then sell the corn to other regions, including domestic markets in Jakarta, Semarang and Makassar, as well as international markets in Singapore, Malaysia, Vietnam, South Korea and the Philippines.

In order to support local corn production, the district government of Bone Bolango has provided various forms of assistance to local farmers. Such assistance includes provision of seedlings, irrigation support and cultivation and processing tools.

4 Existing interventions

4.1 Forest Conservation

Deforestation that occurs in forest zones, especially in national parks, is mostly the result of unclear boundaries between the national park and village areas. This is due to the absence of physical boundaries that are easily recognizable by local people. Therefore, the national park authority (*Balai Taman Nasional Bogani Nani Wartabone SPTN Wilayah I Limboto)* have recently constructed boundary markings that are easily discernible as boundaries of areas prohibited for clearing, to prevent more deforestation within the national park. This effort was also supplemented with engagement interventions with communities surrounding the national park to strongly ban further deforestation.

4.1.1 Develop community-based ecotourism

The national park authority also endeavors to prevent deforestation within the national park via dialogues with local communities to identify more sustainable alternative forest-based livelihoods. These dialogues resulted in a scheme to develop ecotourism in the national park area. This is possible because there are several potential tourist attractions, such as waterfalls, natural hot springs and observations of endemic animals such as maleo birds.

4.1.2 Promote sustainable farming and other alternative income sources

For areas within the national park that have already been deforested and planted by local communities, the national park authority offers some solutions to prevent further agricultural expansion and minimize the negative impacts of deforestation:

- Intensification: In order to prevent agricultural land expansion, intensification of existing agricultural land needs to be done. The national park sees that there is still an opportunity for intensification because the agricultural practices carried out by local communities are not efficient. Sustainable agricultural practices should also be implemented to prevent soil degradation within the national park.
- Diversification: The Bogani Nani Wartabone National Park authority has established an initiative that promotes diversification of crops in already cleared lands within the boundaries of the national park, which was a preferred alternative to enforcing laws towards the actors that cleared the lands. This initiative, referred to as Collaborative Ecosystem Recovery (*Pemulihan Ekosistem Kolaboratif* or PEK), promotes the planting of crops that could produce more profits for local communities, which include candlenut and nutmeg, compared to corn based on the price per kilogram. Such crops were also chosen based on their suitability specifically within the biophysical characteristics of the national park, which could promote the recovery of its ecological functions.

4.2 Sustainable agriculture

4.2.1 Technical assistance

The District Government of Bone Bolango, through the Agriculture and Livestock Agency as well as the Trade and Industry Agency, provides support to coffee farmers and local producers in various forms. From the Agriculture and Livestock Agency, farmers have received basic cultivation tools. In order to increase the efficiency of coffee processing, the District Agency for Trade and Industry has provided two units of processing, with each consisting of hulling, drying, sorting, roasting, grinding, mixing and packing machines. Training in the use of these processing units had also been provided by the Agency to local producers to ensure the proper knowledge transfer. Apart from the district government, other non-governmental stakeholders, such as universities and organizations, also provide support to farmers. For example, the University of Brawijawa has provided training on grafting techniques for propagating coffee trees, and the Sustainable Coffee Platform of Indonesia (SCOPI) has provided training on marketing and branding of Pinogu Coffee.

4.2.2 Incentives and disincentives

While the district government promotes the production of corn, in 2020, it halted the provision of seedlings for local communities who intend to plant in areas with more than 15% slope, to prevent flooding and landslides. Other assistance for corn production will also be halted if there is an indication of encroachment in conservation areas for corn planting. If correctly implemented, this policy will be able to reduce the farmers' motivation to plant corn in steep slope areas. However, based on information gathered from the government agencies and the local community, farmers who grow corn on a steep slope still have access to seedlings due to the lack of verification of the recipient's land by the agricultural extension staff, which lacks the resources to do land verification.

4.2.3 Marketing

In order to support the production of Pinogu coffee, the local government has built two processing hubs in the sub-district. Support is also provided to promote locally produced coffee through a formal agreement between the district government of Bone Bolango and modern convenience stores in the City of Gorontalo to sell Pinogu coffee[21] as well as the establishment of the five Bs program (*Bela, Beli, Buatan Bone Bolango* or Defend for, Buy from, and Made in Bone Bolango). This program seeks to give Bone Bolango products—particularly those made by MSMEs—priority when being purchased. Coffee has also consistently been the centerpiece of Bone Bolango's local goods showcases.

5 Bottleneck Analysis

We conducted an analysis of the steps in each focal commodity's production chain, documenting and describing the steps within each major phase (e.g., cultivation, processing, distribution) and identifying inefficiencies and hindrances ("bottlenecks") within each value chain. Data for the analysis were

[21] https://sulut.inews.id/berita/ritel-modern-jualan-kopi-pinogu-dan-gula-aren-bulango-ulu-dari-umkm-bone-bolango

obtained via interviews with farmers, traders, district agents, among others, as well as from a review of government databases and available literature.

5.1 Non-Timber Forest Products

5.1.1 Palm Sugar

The bottlenecks identified for the palm sugar value chain are summarized in the flowchart (Fig. 12) and table (Table 5) below.

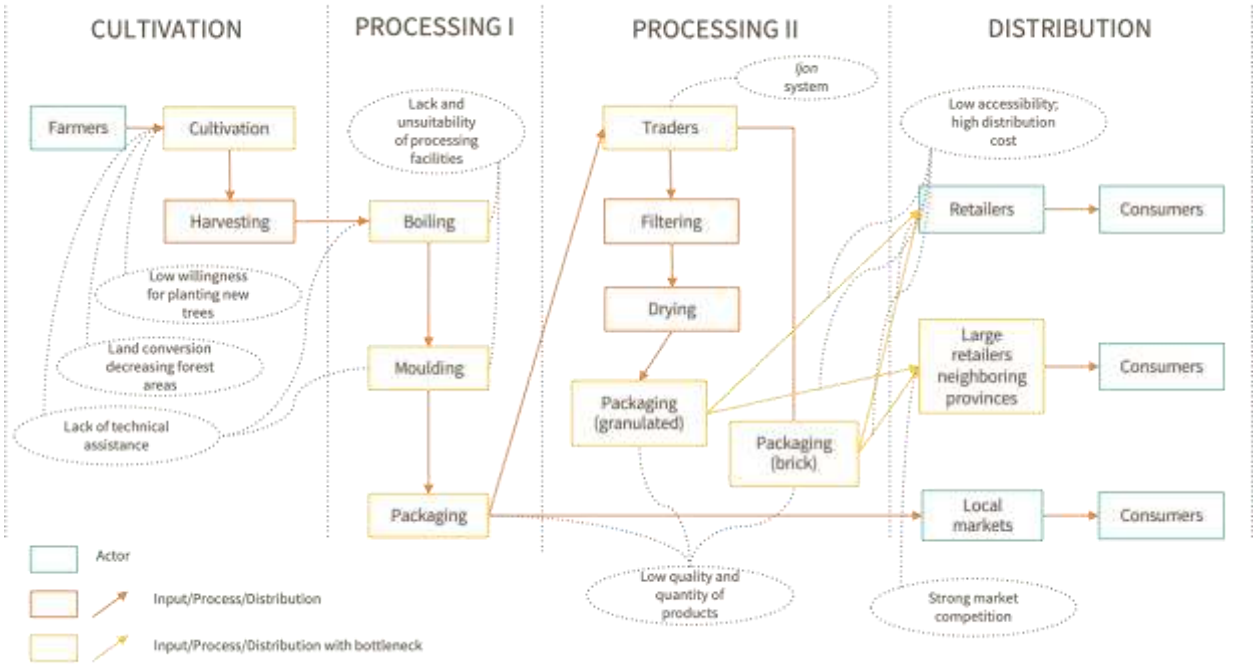

Figure 13. *Flowchart of bottlenecks along the value chain of palm sugar in Bone Bolango District*

Table 5. *Bottlenecks in the value chain of sugar palm in Bone Bolango District*

Stage of Value Chain				
Input	**Production**	**Processing**	**Distribution**	**Sales**
· Expansion of areas for infrastructure development and planting other commodities, especially corn, decreasing areas in which sugar palm trees grow	· Low willingness from farmers to plant sugar palm trees as they have been considered to grow in the wild and planted trees produce lower quality yield, limiting production quantity · Lack of technical assistance provided to farmers	· Low willingness to conduct value-adding processes due to complexity and duration of processing · Lack of technical assistance provided to farmers and local communities to conduct value-adding processes · Lack of technology use to produce palm sugar due to lack of processing facilities, difficulty in using facilities and unsuitability of facilities provided	· High distribution costs, limiting the reach to market	· Sales of produce to middlemen that may give unfair pricing to farmers · Low and inconsistent quality of end products · Strong market competition · Low and inconsistent production volumes to meet international demand

5.1.1.1 Input and Cultivation

Sugar palm trees found in the forest areas of Bone Bolango District are commonly dispersed and propagated naturally without any human interference, and therefore do not require any special cultivation treatment or application of agricultural inputs to grow and become productive. Because of this, farmers are reluctant to plant new trees and conduct proper cultivation practices, such as applying fertilizers, that can help increase the production quantity and quality as it is considered unnecessary. Typically, human intervention occurs only when farmers peel the stalks when the male flowers first appear and tap to stimulate the sap to come out. Several stakeholders, including KPH (Forest Management Unit) and the Agriculture Agency, have attempted to assist farmers in planting and cultivating sugar palm trees by providing seedlings to farmers, which was deemed unsuccessful as farmers considered planting sugar palm trees as unnecessary. Farmers also discovered that the sap generated from the newly planted trees was less than the sap from trees that had been in existence for a considerable amount of time.

For the past few years, the number of sugar palm trees has been declining due to conversion of land for food crops, such as corn, and the building of a reservoir in Bulango Ulu Sub-District, one of the centers for the distribution of palm trees. Without replacement of sugar palm trees or support for alternative economic activities, local communities that have relied on palm sugar as their income source will face challenges in generating household income. The decline in the areas planted with sugar palm trees is expected to result in a decrease in palm sugar production in the district.

5.1.1.2 Processing

As mentioned above, the processing of palm sugar in Bone Bolango is mostly done using traditional methods, despite the government's initiatives to establish production centers, which are only available in one sub-district. According to information gathered from various farmers who process palm sugar, even though advanced technology is available and more efficient than the conventional way, farmers are reluctant to utilize such technology as it can affect the taste of the sugar palm. Furthermore, more financial resources are required to process palm sugar in a modernized manner, and the fact that there are so few processing facilities is what keeps palm sugar processing in a more traditional way. The lack of supply of sap is also one of the causes of the unused production centers, because processing sap in production centers is more profitable for larger volumes.

Traditional sap processing has other impacts on forests. Farmers traditionally use wood for cooking the sap into palm sugar, which is obtained from cutting down trees in the forests, and thus can drive forest degradation. In order to solve this issue, the national park authority had tried to provide rocket stoves, which are substantially more fuel efficient compared to conventional stoves, to some farmers in Bulango Selatan Sub-District.

Traditionally processed palm sugar also has a low level of hygiene because there is no filtering process. Furthermore, it has a sour flavor because the sap is cooked too long, and becomes bitter because it is too close to the stove. Some farmers have been assisted by several stakeholders in the district to transition to employing more hygienic and efficient tools and practices, but they remain resistant to change. One of the reasons is that they don't feel the need to innovate because their products are still doing well on the market.

Most of the processed sap is sold either as brick palm sugar, illegally as traditional liquor (*cap tikus*), or a smaller proportion as granulated palm sugar. Derivative products, like granulated palm sugar, have a higher value when compared to the selling price but take more time to process. Granulated palm sugar is more difficult to sell since they must contend with the equivalent product from other regions, thus they must compete on price, quality, packaging, and a variety of certifications to win market share. In contrast, selling brick palm sugar in conventional packaging to traders or directly to the traditional market is quicker and easier.

5.1.1.3 Sales and Distribution

According to the District Agency for Trade and Industry, the costs associated with logistics and distribution of palm sugar are high, limiting the potential for market expansion. Therefore, at the moment, only local markets in Bone Bolango and the nearby city of Gorontalo sell palm sugar products from Bone Bolango. A limited amount of palm sugar in the form of granulated sugar is offered in supermarkets in addition to traditional marketplaces.

Most of the palm sugar products are sold by farmers to the traders since they provide loans for farmers. The financial reliance that the farmers have on the traders has created an unfair pricing system, as traders have more power in deciding the buying price without enough consideration towards the production costs paid by the farmers and the fair amount of profits that the farmers should receive from the sales. The welfare of the farmers is therefore considerably low.

According to the District Agency for Trade and Industry, the local market for palm sugar has been well established and reached its maximum size, and it is challenging to expand it. With the high distribution cost to export palm sugar to neighboring provinces, market expansion to other regions has been proven difficult.

Efforts to promote locally produced palm sugar have been taken by the district government in order to tap into the international market. The District Head of Bone Bolango has directly promoted palm sugar produced in Bolango Ulu in the Netherlands and Turkey. Such efforts to increase international demands for such products, however, have not been accompanied with adequate supply from the district[22].

5.2 Focus Commodities

One of the main issues with the value chains of many commodities in Bone Bolango District is the setting of the retail prices across different actors along the chain. The common purchasing system particularly found between farmers and traders, called *ijon*, involves upfront agreements and payments from traders to farmers, which the farmers use to fulfill their daily and sometimes urgent needs. Farmers will then give their produce to traders once they have produced enough. This has created heavy financial reliance on traders, and, depending on the urgency for the money, forces farmers to agree with the price set by the traders without much regard to the production cost and profit.

5.2.1 Coffee

Despite its status as an icon of the district with its organic cultivation methods, the production of Pinogu coffee faces many challenges along its value chain. The bottlenecks in the Bone Bolango District coffee value chain of coffee are summarized in the flowchart (Fig 13) and table (Table 6) below.

[22] https://anekamesinpengemas.com/bone-bolango-genjot-pengembangan-produksi-gula-aren/

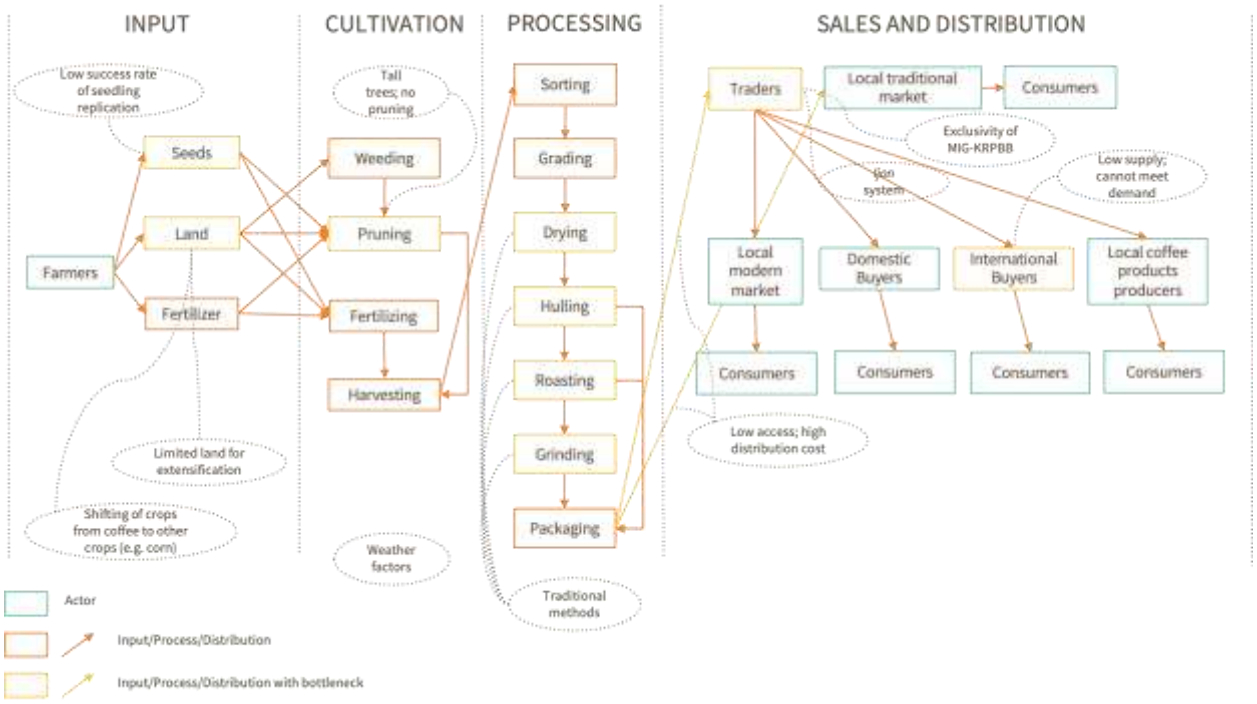

Figure 14. *Flowchart of bottlenecks along the value chain of coffee in Bone Bolango District*

Table 6. *Bottlenecks in the value chain of coffee in Bone Bolango District*

Stage of Value Chain				
Input	**Cultivation**	**Processing**	**Distribution**	**Sales**
· Poor supply of seedlings that meet the standards and specifications for planting in Pinogu Sub-district · Shifting of crops from coffee to other, more "lucrative" crops (mainly corn), as observed in Ilomata Village	· Low implementation of good, organic farming practices (e.g. pruning) due to lack of willingness and access to information	· Limited use of technology and processing facilities by farmers due to farmers' belief that they will produce inferior products · Low implementation of value-adding processes, particularly in accordance with the standards of certified "Pinogu Coffee" due to lack of willingness, benefits for farmers and access to information	· Low accessibility to and from production sites, especially from Pinogu that is located within Bogani Nani Wartabone National Park, causing high distribution costs	· Limited production volumes cannot meet large domestic and international demands · Unclear procedures to sell certified "Pinogu Coffee" to the market and use of the "Pinogu Coffee" label protected under the geographic indication certificate, hindering farmers from selling their products in fear of misusing the label

5.2.1.1 Input and Cultivation

The District Agency for Agriculture and Livestock of Bone Bolango plans to plant more trees in the area to increase production. However, to maintain the quality and reputation of the coffee that has already been established in the market, it is deemed important to ensure that the coffee produced by the new trees shares similar characteristics of the traditional Pinogu coffee. This has hindered the government's efforts in supporting farmers through provision of seedlings; the Agriculture Agency has provided farmers with seedlings of coffee trees that do not grow well in Pinogu's climate. Research and development have been conducted together with the Research Institute for Industrial and Beverage Crops (*Balai Penelitian Tanaman Industri dan Penyegar* or Balittri), under the Ministry of Agriculture, in order to produce seedlings that meet such criteria. Unfortunately, according to the District Agency, the research and development process has been slow, and the replication of such seedlings currently has only a 50% success rate. The national park authority and local organizations have also started to develop the *liberica* coffee variety in the Pinogu non-forest use area because this variety has been planted for more than a hundred years in the national park area. This can also be an alternative for coffee development in Pinogu.

As mentioned above, the district of Pinogu is located within the boundaries of a national park. Therefore, there is a limitation to extensification in order to increase the coffee production, and a comprehensive study is needed to know the optimum area to develop coffee in Pinogu sub-district. According to the spatial analysis conducted using the district's most recent spatial plan (*Rencana Tata Ruang Wilayah*) and land cover data, there are 755 hectares of secondary forests and 624 hectares of shrubs within the non-forest use area in Pinogu that are located within the allocated land for plantation crops, including coffee, which could be used for the extensification of coffee in the sub-district to boost the district's coffee production.

In other areas, many coffee farmers have traded their coffee trees for corn plants, due to their belief that corn production will generate more income compared to coffee production. This has been observed in Ilomata Village in Bulango Ulu Sub-District. While corn production may generate stable and frequent income due to its shorter planting cycle, compared to that of coffee, and more established market, many studies[23] state that corn production does not produce income that is higher than coffee production.

Bottlenecks were also identified in the cultivation phase of the production. Based on interviews and discussions with local producers and stakeholders, farmers are reluctant to prune their trees due to fear that pruning will reduce the yield of production and that they will lose their income. Pruning is a crucial part of coffee cultivation practices as it stimulates coffee production by exposing trees to more sunlight, eliminating damaged plant tissues, and reducing the favorable conditions for pests and diseases[24]. Therefore, without proper pruning, the productivity of the existing coffee trees is not maximized. The productivity of coffee in Bone Bolango District is around 230 kg/ha/year, which is substantially low compared to the average productivity of coffee trees in Indonesia that reaches 750 kg/ha/year. Socialization on the importance of proper maintenance of the existing trees has been taken

[23] Murtisari, A. (2015). Pendapatan, Sumber dan Distribusi Pendapatan Rumah Tangga Petani Jagung di Kabupaten Bone Bolango. Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah, 2(3), 129-134.

[24] coffee-pruning-and-management.pdf - ECHOcommunityhttps://assets.echocommunity.org › presentations

by the district government, although, according to the District Agency of Agriculture and Livestock, it has not been successful in shifting cultivation practices among farmers to incorporate pruning.

Pinogu coffee beans are susceptible to weather changes, particularly rainfall. During a prolonged dry season, the coffee beans will shrink, and during a prolonged wet season, they will fall and rot[25]. The extended dry season also causes the skin of ripe coffee cherries to become hollow and the coffee beans to become dark and porous. Most of the time, these damaged coffee beans can still be sold, but only for a very low price and without the Pinogu brand[26].

5.2.1.2 Processing

Processing of Pinogu coffee consists of sorting, grading, drying, grinding and packaging, and most of these processing stages are still done using traditional methods. For example, many local producers of Pinogu coffee still use clay woks for roasting dried coffee beans prior to grinding[27]. Despite having access to processing tools and machines as provided from the District Government, through the District Agency for Trade and Industry, many producers still rely on traditional processing methods as they believe they will produce better aromas and quality of the end products. The reliance on traditional processing methods will limit the efficiency of the production.

Pinogu coffee is certified for geographic indication, which could increase the competitiveness of Pinogu coffee in the domestic and international coffee market. However, according to interviews and discussions with several local actors and stakeholders, not all producers in the sub-district are willing to produce and process their coffee according to the production and processing standards set through the certification due to a lack of access to information on the standards themselves as well as the skepticism that such certification would bring tangible benefits to the producers. Also, according to the interviews, only several producers in the sub-district can legally label their products as "Pinogu Coffee". Therefore, the benefits of the certification are only felt by a handful of people and such exclusivity has led to counterfeiting, jeopardizing the reputation of Pinogu coffee in the domestic and international markets due to unknown quality assurance.

5.2.1.3 Sales and Distribution

Considering that Pinogu Sub-District is located in the remote area within the boundaries of a national park, access to and from the sub-district is heavily limited, with poorly constructed roads in poor condition, especially in inclement weather. While this is expected as access to national parks should be limited to discourage encroachment, this has made the distribution of crops produced in Pinogu, including coffee, particularly challenging, costly and time consuming. According to interviews with the District Agency for Trade and Industry and local coffee farmers in Pinogu, the cost associated with transporting coffee from the sub-district to the nearest city could be between IDR 300,000 - IDR 500,000 per trip, with a maximum capacity of 100 kilograms (IDR 3,000 - IDR 5,000 per kilogram).

[25] Mooduto, W. I. S., et al. 2021. Analysis of Pinogu Coffee Supply Chain in Bone Bolango. Jurnal Pascasarjana, 6(2).
[26] https://lipunaratif.com/aroma-kopi-dan-nestapa-masyarakat-pinogu/
[27] Mooduto et al. 2021.

Because of limited coffee production in Bone Bolango District, exporting coffee to larger markets could be challenging, as exports generally demand large volumes of quantity that cannot be met by the supply from Pinogu Sub-District. Although interventions and programs can be aimed at increasing the productivity of existing coffee trees and using currently available lands in the Sub-District, the relatively small size of land that is allowed for coffee farming will always limit the total production quantity.

Based on interviews conducted with local coffee producers in Pinogu Sub-District, there is a lack of clarity among producers in regards to the legal use of the "Pinogu Coffee" label in accordance with the geographic indication certification. Farmers fear that the mislabeling would subject them to legal sanctions, and therefore sell their produce under different labels.

5.2.2 Corn

The bottlenecks identified for the corn value chain are summarized in the flowchart (Fig. 14) and table (Table 7) below.

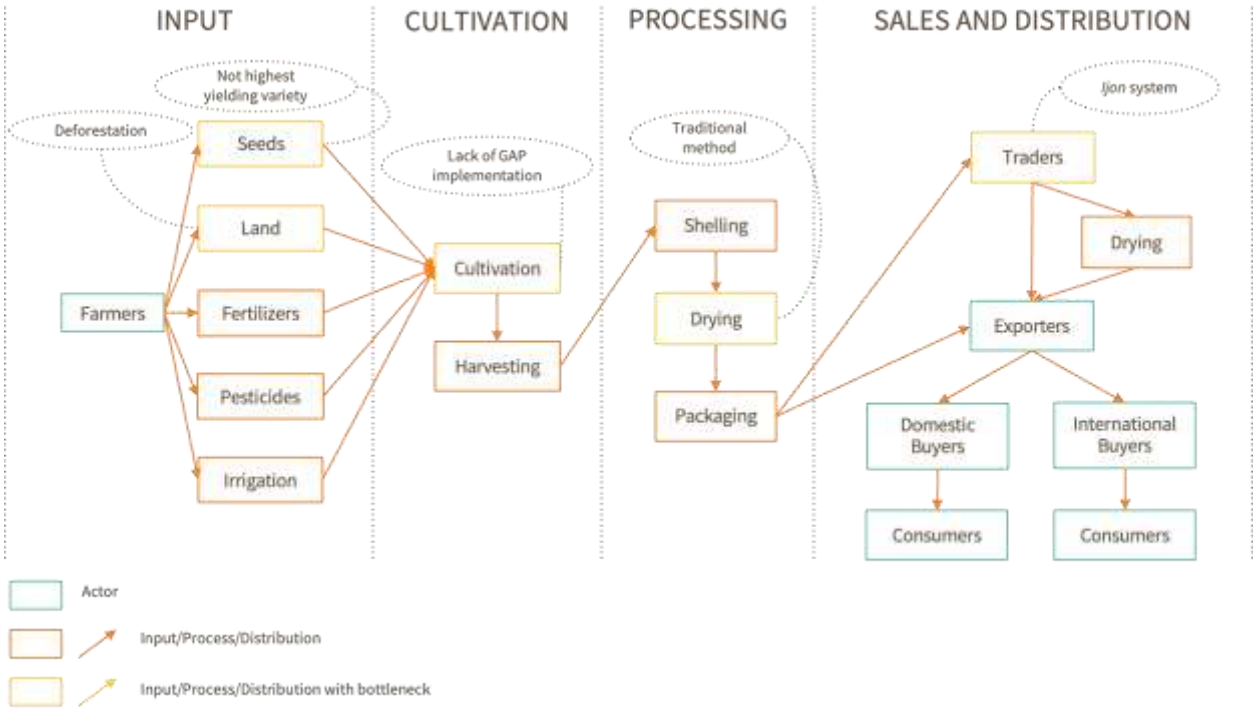

Figure 15. *Flowchart of actors along the corn value chain in Bone Bolango District*

Table 7. *Bottlenecks in the value chain of corn in Bone Bolango District*

Stage of Value Chain				
Input	**Cultivation**	**Processing**	**Distribution**	**Sales**
· Seeds of lower productivity provided by the government · Inadequate system for identifying appropriate beneficiaries of government support, resulting in support directed to people without agricultural lands that lead to land clearing in forested areas	· Lack of technical assistance provided to farmers for improving farming practices due to limited local human resources	· Lack of drying facilities provided by the government, resulting in many farmers still using inefficient traditional drying methods	·	· Lack of market demand for derivative corn products

5.2.2.1 Input and Cultivation

To support corn production in the district, the District Government of Bone Bolango, through its Agriculture and Livestock Agency, has provided farmers with corn seeds. The varieties of corn seeds provided by the Agency include NK 212 and BISI 18, as these varieties are requested by farmers and fit into the Agency's budget. However, there are other varieties, such as NK Sumo and NK Perkasa, that have higher levels of productivity. However, the prices of the seeds are higher than the NK 212 and BISI 18 varieties. The seeds of NK 212 and BISI 18 varieties are priced at IDR 80,000 per kilogram, whereas the seeds of NK Sumo are priced at IDR 100,000 per kilogram. Therefore, to procure seeds of higher productivity level, farmers would require more financial resources; with the limited district budget, the provision of seeds of the more productive varieties cannot be implemented by the District Government.

The provision of such support should be based on proper identification of recipients. However, in the case of Bone Bolango District, many people receive corn seeds from the District Government despite not having any agricultural lands, or having corn plants planted in prohibited areas, such as sloped lands that are prone to erosion. Without proper identification of recipients, more people will be motivated to convert forests and other areas that are not suitable for corn farming into corn plantations, and will further promote unsustainable corn farming practices.

Bottlenecks have also been identified in the cultivation of corn in Bone Bolango District. Many corn farmers are still unaware of efficient cultivation techniques due to lack of technical assistance provided to farmers for improving farming practices. As a result, farmers' production is lower, which drops their potential profit.

5.2.2.2 Processing

As described above, the drying process is a crucial value-adding process, as the prices of corn in the market depend on the water content in the produce. While there are tools and facilities provided for farmers to dry their produce properly, such support is limited and does not provide enough capacity to process all produce in the district. As a result, many farmers and processes still rely on the sun, and the

suboptimal post-harvest processing has caused difficulties in ensuring that corn kernels are dried properly and reach the desired water content.

5.2.2.3 Sales and Distribution

The market already established for corn is mostly for animal feed and human consumption, without much demand for derivative products. The District Agency for Trade and Industry saw an opportunity for local farmers and processors to produce derivative products from corn, such as corn chips. However, the market for such products is currently too small and therefore is not attracting farmers and processors.

6 Trade-offs

Stakeholders in the district face a series of economic, social, and environmental trade-offs on the path to sustainable, forest-friendly development. On the one hand, forest conversion for tree plantations and cropland to make way for agriculture provides direct economic benefits, including food security and economic revenues. On the other hand, forest conversion also generates costs that are more indirect and less appreciated, including those associated with disasters, soil erosion, fire, air pollution, loss of biodiversity. Forest conversion also generates several costs associated with the loss of direct economic benefits derived from keeping forests standing, such as food provision, NTFPs and ecotourism. Thus, there is an *opportunity cost* to converting forest for cropland: when one alternative is chosen (i.e., income from croplands), other alternatives are lost (i.e., NTFP and ecotourism income, environmental protection, etc.). The *opportunity* of agricultural income, in this case, comes with a *cost* of the lost benefits of the standing forest.

Understanding these alternatives and their respective costs is necessary to design appropriate, effective incentive mechanisms and interventions to achieve the district's economic and environmental goals. Specifically, it is important to understand the cost to individual farmers of *forgoing* crop- or tree-cultivation on cleared forest lands in favor of keeping forest standing, as this represents much of the cost of forest conservation. This opportunity cost is calculated as follows:

Opportunity cost of Forest Conservation = Value of Forgone Profits from Forest-replacing Agriculture - Value of Benefits of Forest Conservation

In this study, we estimated the typical profits that farmers can expect to generate from producing each of the focus commodities as a measure of the potential forgone profits associated with forest conservation. We also estimated the economic benefits derived directly from forests, including from the harvest of non-timber forest products (NTFPs) and ecotourism activities. We combined these costs to estimate the economic value of standing vs cleared forests from the perspective of local farmers. Details of the methodologies used for calculating these values can be found in Appendix 1.

6.1 Value of agricultural production

The annual value of agricultural production was estimated from a survey of production costs (inputs, labor, equipment, etc.) and revenues for each of the focus commodities (coffee, corn), collected via interviews with farmers and relevant district-level agencies in Bone Bolango District. To reflect the actual costs incurred, labor costs were assumed to be negligible for all estimates presented below—unless stated otherwise--under the assumption that the work done by farmers and family members is not remunerated. However, calculations reflecting alternative scenarios in which the same work is remunerated are provided in Appendix 1.

6.1.1 Coffee

In this study, estimates of the average yearly production costs and revenues associated with the coffee value chain were restricted to Pinogu Sub-district (Table 8; Table 9). The labor costs cited here are the actual costs paid by farmers to hire additional workers. The labor costs that include the work farmers and their family members are not explicitly included—as explained above—and are presented in Table A1 in Appendix 1.

Table 8. *Costs associated with coffee production in Pinogu Sub-district, Bone Bolango District*

Activity	Average Yearly Production Costs (IDR)		
	Input	Machines and Equipment	Labor
Land preparation	-	5,060,000	6,700,000
Pre-planting	1,250,000	3,000,000	-
Planting	-	793,000	2,025,000
Post-planting	-	65,000	-
Cultivation	4,480,000	1,010,000	13,710,000
Pre-harvesting	-	-	-
Harvesting	-	122,000	9,410,000
Post-harvesting	562,500	1,300,000	7,800,000
Processing	385,000 (RB)	2,975,000 (GB) 3,520,000 (RB) 6,610,000 (GC)	6,250,000 (RB)
Packaging	675,000 (GB 1 kg) 125,000 (GB 50 kg) 180,000,000 (GC 10 g) 33,000,000 (GC 50 g) 10,615,000 (GC 100 g) 4,078,500 (GC 200 g) 3,792,000 (RB 200 g) 2,216,000 (RB 500 g) 1,392,000 (RB 1 kg)	1,265,000 (GC 100 g) 665,000 (GC 200 g) 665,000 (RB 200 g) 305,000 (RB 500 g) 185,000 (RB 1 kg)	-
Transportation/ distribution	-	3,375,000 (GB) 2,250,000 (RB) 2,625,000 (GC)	-
Sales/marketing	-	-	-

GB = green beans; RB = roasted beans; GC = ground coffee

Table 9. *Average yearly revenue for coffee farmers in Pinogu Sub-district, Bone Bolango District*

Product	Price	Revenue (IDR/person/year)
Green beans	27,500/kg	4,752,500
Roasted beans - 200 gr	30,000/200 gr	8,400,000
Roasted beans - 1 kg	105,000/kg	7,140,000
Ground coffee - 10 gr	1,000/10 gr	23,300,000
Ground coffee - 50 gr	4,750/50 gr	15,430,000
Ground coffee - 100 gr	17,500/100 gr	15,430,000
Ground coffee - 200 gr	26,500/200 gr	8,680,000

Coffee in Pinogu is transformed into a variety of products that are priced differently, depending on the value-adding processes. Typically, coffee produced in Pinogu is sold as green beans, roasted beans or ground coffee. These products are sold in varying volumes and prices, according to market demand.

There are a number of factors contributing to the differences in coffee prices. In Pinogu, coffee is sold in many quality grades, which define the coffee price. Farmers transform their coffee into different products depending on a number of other factors such as market demands, farmers' capacities and available technology. Processing coffee beans into ground coffee increases their value at a ratio of approximately 82.13, which is considered a high value-added ratio[28] (VAR). Nevertheless, coffee prices vary depending on the quality of the final product. Actors along the supply chain also play a role in determining the prices of the coffee, and, unlike corn, neither local nor national governments regulate the prices of Pinogu coffee.

In addition to sale prices, the revenues obtained by farmers from coffee production also depend on the total area of land that farmers plant with coffee trees. On average, the total land area for coffee trees owned and planted by a farmer is 3 ha. The calculation of farmers' profits used a per-hectare basis to provide a comparable assessment between farmers (Table 10); a per-capita basis was used to provide a comparable assessment between the net present value of profits from coffee production and benefits of forest conservation (details provided in Appendix 1).

Table 10. *Profits generated by interviewed coffee farmers in Pinogu Sub-District, Bone Bolango District*

Product	Profit (IDR/person/year)
Green beans	(-400,979)
Roasted beans - 200 gr	3,487,436
Roasted beans - 500 gr	2,259,169
Roasted beans - 1 kg	3,026,393
Ground coffee - 10 gr	-26,590,875
Ground coffee - 50 gr	1,953,430
Ground coffee - 100 gr	6,301,804
Ground coffee - 200 gr	3,778,543

[28] Mooduto et al. 2021.

The profits were subsequently projected over a 30-year time horizon to obtain the Net Present Value per capita (Table 11).

Table 11. *Net Present Value (NPV) of coffee production in Bone Bolango District*

Product	Value (IDR/person/year)
Green beans	(-6,565,012)
Roasted beans - 200g	57,097,876
Roasted beans - 500g	36,988,141
Roasted beans - 1kg	49,549,472
Ground coffee - 10g	(-435,357,799)
Ground coffee - 50g	31,982,439
Ground coffee - 100g	103,175,980
Ground coffee - 200g	61,864,011
Median value	43,268,807

6.1.2 Corn

Based on the series of interviews conducted with farmers and relevant district-level agencies in Bone Bolango District, the average yearly production costs and revenues associated with the corn value chain in Bone Bolango District (Table 12; Table 13).

Table 12. *Costs associated with corn production in Bone Bolango District*

Average Yearly Production Costs (IDR)			
Activity	**Input**	**Machines and Equipment**	**Labor**
Land preparation	3,761,000	3,580,000	-
Seed/seedling production/procurement	6,000,000	-	-
Planting	-	-	-
Post-planting	2,400,000	80,000	-
Cultivation	13,600,000	2,000,000	–
Pre-harvesting	-	30,000	-
Harvesting	-	-	-
Post-harvesting	-	-	-
Processing	-	2,225,000	-
Packaging	80,000	2,000,000	-
Transportation/ distribution	-	-	-
Sales/marketing	-	-	-
Total	25,841,000	9,915,000	-

Table 13. *Average yearly revenue for corn farmer in Bone Bolango District*

Product	Price per kg	Revenue (IDR/person/year)
Dried corn kernels	4,800	10,800,000

The price of corn varies depending on water content. According to the District Agency for Agriculture and Livestock, the price of corn sourced from traders vary between IDR4,900-IDR4,950 per kilogram (for corn with a water content between 15-17%) and IDR4,750-IDR4,850 per kilogram (for corn with a water content between 18-30%). If sourced from exporters, the prices increase slightly, to IDR5,000 per kilogram and IDR4,950 per kilogram, respectively. As mentioned above, the prices of corn are regulated by the national government to maintain price stability, ensuring that farmers receive fair share of profits and consumers do not overpay. The profits generated by corn farmers in Bone Bolango District are shown in Table 14 below.

Table 14. *Profits generated by interviewed corn farmers in Bone Bolango District*

Product	Profit (IDR/person/year)
Dried corn kernels	5,094,992

The profits were subsequently projected over a 30-year time horizon to obtain the Net Present Value per capita (Table 15).

Table 15. *Net Present Value (NPV) of corn production in Bone Bolango District*

Product	Value (IDR/person/year)
Dried corn kernels	83,417,502

6.2 Benefits of Forest Conservation-based Activities

6.2.1 Direct benefits from forest conservation-based activities

6.2.1.1 Non-timber forest products

The non-timber forest products (NTFPs) included in this study are palm sugar and rattan. Both have been legally allowed by KPH (Forest Management Unit) VII Bone Bolango to be taken by the community through the long-term forest development plan[29].

[29] Rencana Pengelolaan Hutan Jangka Panjang KPHP unit VII Bone Bolango 2016-2025.

6.2.1.1.1 Palm Sugar

Based on the series of interviews conducted with farmers and relevant district-level agencies in Bone Bolango District, the average yearly production costs incurred along the value chains of palm sugar produced in the district, as well as the average yearly revenues, throughout the 30-year projection were acquired and presented in Table 16 and Table 17 below.

Table 16. *Costs associated with palm sugar production in Bone Bolango District*

Average Yearly Production Costs				
Activity	**Input**	**Machines and Equipment**	**Labor (if work of farmers and their family members is remunerated)**	**Labor (if work of farmers and their family members is not remunerated)**
Land preparation	-	-	-	-
Pre-planting	-	-	-	-
Planting	-	-	-	-
Post-planting	-	-	-	-
Cultivation	-	-	-	-
Pre-harvesting	-	1,010,000	3,600,000	-
Harvesting	2,600,000	-	25,200,000	-
Post-harvesting	-	-	-	-
Processing	-	60,000	25,200,000	-
Packaging	707,200	-	-	-
Transportation/ distribution	-	-	520,000	-
Sales/marketing	-	-	-	-
Total	3,307,200	2,140,000	54,520,000	-

Table 17. *Average yearly revenue for sugar palm farmers in Bone Bolango District*

Product	**Price per kg**	**Annual revenue (IDR/person/year)**	**Profit (IDR/person/year)**	**Value (IDR/person/year)**
Brick sugar	17,000	7,756,250	6,394,450	104,692,819

Palm sugar in Pinogu is transformed into two different products (brick sugar and granulated sugar) that are priced differently. Typically, palm sugar produced in Pinogu is produced as brick sugar, while granulated sugar is only produced on demand. Thus, granulated palm sugar is excluded from this calculation.

6.2.1.1.2 Rattan

Rattan can be found in forests in 8 of the 18 sub-districts in Bone Bolango District, which are Bone, Bone Pantai, Botupingge, Bulango Ulu, Bulango Utara, Kabila Bone, Suwawa Selatan and Suwawa Timur

sub-districts. Data from the KPH showed that there were more than 1,500 rattan plants that had been surveyed, of which 600 were large in size with a diameter of more than 3 meters.

Communities that harvest rattan usually sell it to IKM (small enterprise) rattan craftsmen or directly to traditional markets. Income from rattan is usually not the main source of income for individuals, who rely more on income from farming, such as chilies, peanuts, bananas, candlenuts and cloves. The community's income from harvesting rattan from the forest is not large, only around IDR 1,900,000 per year per household[30] or about 63% of the regional minimum salary. The net present value per capita of rattan products is IDR 31,107,656.

Table 18. *Average yearly revenue for rattan farmers in Bone Bolango District*

Product	Profit (IDR/person/year)	Value (IDR/person/year)
Rattan	475,000	7,776,914

6.2.1.2 Tourism

6.2.1.2.1 Ilomata Rivercamp

The Ilomata Rivercamp was established as a tourist attraction in 2018, using village funds and national park authority investments of around IDR 100 million. The ticket price of IDR 300,000 per tent (4 people) includes the National Park entrance ticket, vehicle parking and meals. There is no visitors data, but according to the head of the national park authority, it is safe to assume every week there are at least 15 tents filled, thus the annual revenue would be IDR 234,000,000. We estimated an average annual cost of IDR 13,400,000, yielding an annual profit around IDR 220,600,000. As the total village population is 535 people, the annual profit per capita is around IDR 412,000.

6.2.1.2.2 Lombongo Waterfall

The entrance ticket of Lombongo waterfall in Lombongo village is IDR 19,000 for adults and IDR 10,000 for children. As the average visitors per week is 1,000 and assuming half of them are adults and the other half are kids, the annual revenue is 754,000,000. The annual profit per capita is IDR 658,000 as the total village population is 1,146.

Table 19. *Average yearly revenue from tourism in Bone Bolango District*

Tourism spot	Profit (IDR/person/year)	Value (IDR/person/year)
Ilomata rivercamp	412,000	6,745,449
Lombongo waterfall	658,000	10,773,072

[30] Harun, A. (2016). Pemanfaatan Hasil Hutan Non Kayu terhadap Peningkatan Pendapatan Petani Hortikultura di Desa Molotabu Kecamatan Kabila Bone Kabupaten Bone Bolango.

6.2.2 Indirect benefits from forest conservation

Forests also provide various other indirect benefits to the broader community, beyond the direct benefits that can be obtained by those who live nearby. In this study, we estimated[31] the economic value of seven ecosystem services that forests in the region provide: water regulation, air quality regulation, flood, landslide and forest and land fire mitigation, biodiversity, and carbon storage (Table 20).

Table 20. *Economic indirect benefits of forest conservation in Bone Bolango*

Ecosystem services	Value(IDR/person/year)
Water regulation	3,254,198
Air quality regulation	120,968,435
Disaster mitigation: flood	70,902,516
Disaster mitigation: landslide	58,700,457
Disaster mitigation: forest and land fire	77,378,048
Biodiversity	1,010,578
Carbon sequestration and storage	14,621,140

6.2.2.1 Water regulation

Many of the forests in Bone Bolango District are located in the upstream areas of the Bone River, which in turn can benefit the people living in the downstream areas, where most of the settlement areas in the district are located. Some of the benefits for communities in downstream areas are adequate supplies of groundwater, preventing flash floods during torrential rains and getting enough water for agricultural irrigation. In order to preserve upstream forests, communities living in these areas need to limit their land expansion and find livelihood alternatives. Currently there are several types of incentives that can be given to the community or local government to maintain forests in order to support the livelihood of people in other areas, one of which is Payments for Ecosystem Services (PES). In this study, the PES scheme for water regulation in Cidanau watershed[32] is implemented. The total forest cover in Bone Bolango District is 132,428 ha. Applying a price of IDR 4 million/ha/year, the total benefit from forest conservation for water regulation in Bone Bolango could reach IDR 529.71 billion/year.

6.2.2.2 Air quality

In this study, we estimate the value of forests in terms of their ability to enhance air quality using a methodology that has been tested in Wuhan, China[33]. In total, there are four ecological services values

[31] A detailed description of the methods employed for these estimates is provided in Building Resilient, Inclusive, Forested Jurisdictions in Indonesia, Bone Bolango District: Full Report.

[32] Budhi, Gelar Satya, S. A. Kuswanto, and Muhammad Iqbal. "Concept and implementation of PES program in the Cidanau watershed: a lesson learned for future environmental policy." Analisis Kebijakan Pertanian 6.1 (2008): 37-55.

[33] Xie, Q., Yue, Y., Sun, Q., Chen, S., Lee, S. B., & Kim, S. W. (2019). Assessment of ecosystem service values of urban parks in improving air quality: A case study of Wuhan, China. Sustainability, 11(22), 6519.

that are calculated, including O_2 generation, air temperature amelioration, SO_2 removal and NO_x removal. The economic value of each ecosystem service is shown in Table 20.

Table 21. *The total economic value of forests in enhancing air quality in Bone Bolango District*

Ecosystem services	Total Value (billion IDR/year)
O_2 generation	17,761
Air temperature amelioration	36
SO_2 removal	132
NO_x removal	1,762
Total	19,691

6.2.2.3 Disaster mitigation: flood, landslide and forest and land fire

The methodology for estimating disaster-related economic loss developed by the National Agency for Disaster Mitigation is employed to estimate the value of forest ecosystem mitigation of flood[34], landslide[35] and forest and land fire[36] impacts. The risk level of each disaster is shown in Figure 16 a, b and c and is classified as:

- Low ($H \leq 0.333$)
- Moderate ($0.333 \leq H \leq 0.666$)
- High ($H > 0.666$)

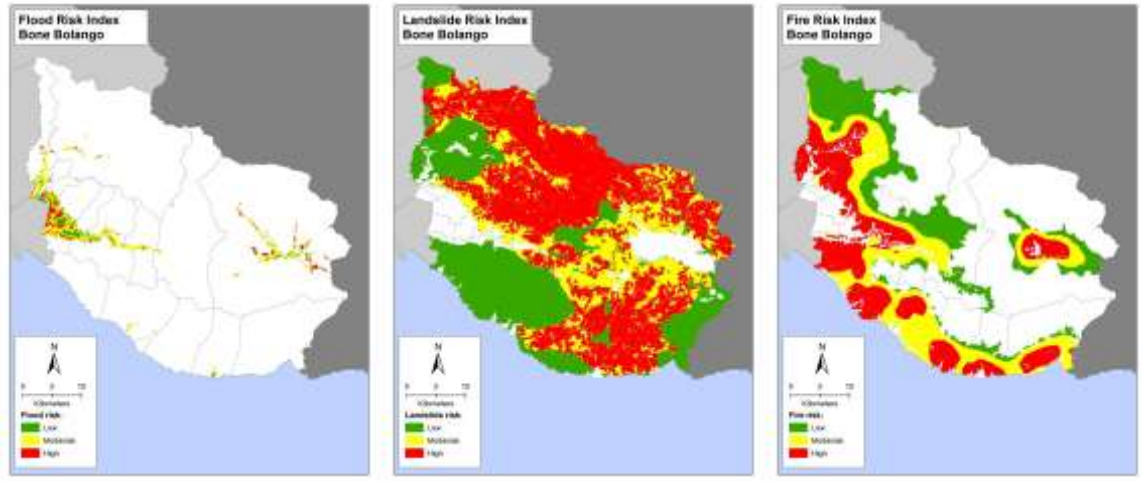

Figure 16. *Map of risk level of (a) flood; (b) landslide; and (c) forest and land fire*

[34] Badan Nasional Penanggulangan Bencana. (2019). Modul Teknis Penyusunan Kajian Risiko Bencana Banjir. Jakarta, Indonesia: Direktorat Pengurangan Risiko Bencana BNPB.

[35] Badan Nasional Penanggulangan Bencana. (2019). Modul Teknis Penyusunan Kajian Risiko Bencana Tanah Longsor. Jakarta, Indonesia: Direktorat Pengurangan Risiko Bencana BNPB.

[36] Badan Nasional Penanggulangan Bencana. (2019). Modul Teknis Penyusunan Kajian Risiko Bencana Tanah Longsor. Jakarta, Indonesia: Direktorat Pengurangan Risiko Bencana BNPB.

The economic loss is estimated by calculating the number of buildings located within each of the disaster risk zones identified by BNPB. While a complete building footprint data necessary to do this calculation is not available, these data are estimated by calculating the building density using the available data from OpenStreetMap and settlement area from BIG (*Badan Informasi Geospasial*/Geospatial Information Agency). These buildings are then divided into three types of damage rate, including Low: no damage; Moderate: 50% of the number of houses affected by light damage multiplied by the regional price unit; and High: 50% of the number of houses affected by moderate damage multiplied by the regional price unit, and 50% of the number of houses affected by heavy damage multiplied by the regional price unit. The light, moderate and heavy damage costs 25%, 50% and 100% of the regional price unit, respectively. Table 22 shows the total buildings potentially impacted by each disaster and Table 23 shows the estimated potential economic loss from building damage.

Table 22. *Number of buildings potentially affected by natural disaster in Bone Bolango District*

Risk level	Number of building		
	Flood	Landslide	Forest and land fire
Low	2,890	3,180	5
Moderate	7,426	291	21
High	760	37	40

Table 23. *Potential economic loss from building damage due to natural disaster in Bone Bolango District*

Risk level	Economic loss from building damage (Million IDR)		
	Flood	Landslide	Forest and land fire
Low	0	0	0
Moderate	167,085.00	6,547.50	472.50
High	102,600.00	3,995.00	5,400.00
Total	269,685.00	10,542.50	5,872.50

6.2.2.4 Biodiversity

The approach used to estimate the economic benefit of forest conservation for preserving biodiversity is by estimating the cost of offsite protection of rare and endangered species[37]. The rare and endangered species are identified by referring to the IUCN (International Union for Conservation of Nature) Red List of Threatened Species. In Bone Bolango, the species are Anoa (Bubalus depressicornis), Maleo Senkawor (Macrocephalon maleo) and Blue-faced rail (Gymnocrex rosenbergii). Then, the distribution patterns of suitable habitats for rare and endangered species are predicted spatially. In total, the area of suitable habitats for these three species in Bone Bolango is 2,551 ha. There are five costs included to estimate the offsite protection cost of rare and endangered species, which are labor costs, land lease costs, forest pest control chemicals, chemicals for disease and pest control in grassland and agricultural irrigation costs. The total annual cost for offsite protection is IDR 644,841,904,600 per ha and the total cost is IDR 164.5 Billion, of which 64%, 16% and 14% of the total costs contributed by labor costs, land lease costs and pest control and irrigation costs.

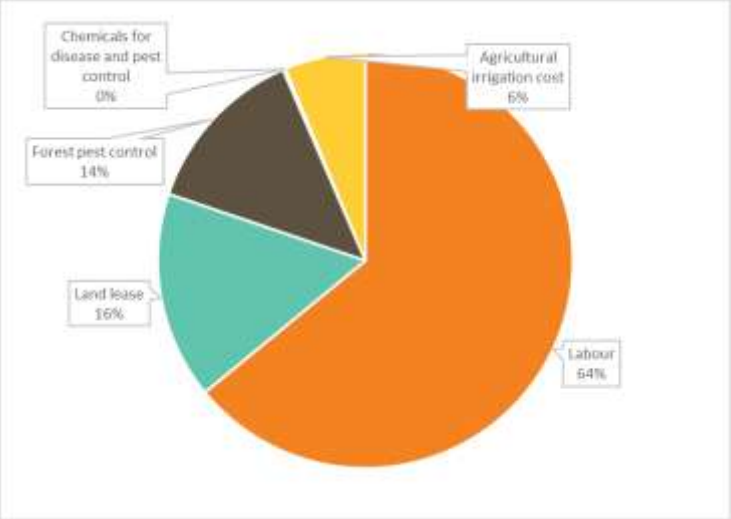

Figure 17. *Proportion of annual offsite protection costs of rare and endangered species*

6.2.2.5 Carbon sequestration and storage

6.2.2.5.1 Aboveground biomass (AGB)

The estimation of aboveground biomass (AGB) is carried out by applying the mean AGB as estimated by the Ministry of Environment and Forestry[38] via surveys conducted for each forest type in Indonesia.

[37] Zhao, X., Wang, J., Su, J., Sun, W., & Meng, H. (2021). Research on a Biodiversity Conservation Value Assessment Method Based on Habitat Suitability of Species: A Case Study in Gansu Province, China. Sustainability, 13(6), 3007.

[38] MoEF, 2015, National Forest Reference Emission Level for Deforestation and Forest Degradation: In the Context of Decision 1/CP.16 para 70 UNFCCC (Encourages developing country Parties to contribute to mitigation actions in the forest sector), Directorate General of Climate Change. The Ministry of Environment and Forestry.Indonesia.

On Sulawesi Island, at least 433 measurement plots have been carried out, which results in a mean AGB for primary dryland forest and secondary dryland forest of 275.2 t/ha and 206.5 t/ha, respectively.

6.2.2.5.2 Biomass conversion to carbon

To estimate the amount of carbon (C) in each forest type, information on carbon fraction is needed. The carbon fraction of biomass (dry weight) was assumed to be 47% (1-ton biomass = 0.47 tons C) following the IPCC 2006 Guideline.

Table 24. *Economic values of forests carbon storage in Bone Bolango*

Forest area 2019 (ha)	Mean AGB (t/ha)	Total AGB (t)	Total C (t)	Carbon storage economic values (million IDR)
Primary: 93,426 ha	275.2	25,710,835	12,084,093	1,812,613
Secondary: 39,002 ha	206.5	8,053,913	3,785,339	567,800
Total		33,764,748	15,869,432	2,380,413

6.3 Trade-offs estimation

The annual value of agricultural production was estimated[39] from a survey of production costs (inputs, labor, equipment, etc.) and revenues for each of the three focus commodities (coffee, corn, palm sugar) (Table 25). Coffee is typically processed and sold by farmers in one of eight alternative forms: green beans, roasted beans (in volumes of 200g, 500g or 1kg) and ground coffee (in volumes of 10g, 50g, 100g or 200g). The value of other forest-based economic activities (rattan, eco-tourism) was also estimated based on harvest, processing, operating costs and investments and revenues for each respective activity. Although palm sugar is a focus commodity for the Bone Bolango District government, since the trees are wild-growing in forests, we classified the palm sugar as a forest-dependent non-timber forest product.

Table 25. *Potential profits of focus commodities and benefits of forest conservation in Bone Bolango*

Source of income		Value (IDR/person/year)
Focus commodities	Ground coffee - 10g	0 (-435,357,799)
	Ground coffee - 100g	103,175,980
	Coffee - median value	43,268,807
	Corn - dried kernels	83,417,502
Forest-based activities	NTFPs - Palm sugar - Brick sugar	104,692,819
	NTFPs - Rattan	7,776,914
	Tourism - Ilomata river camp	6,745,449
	Tourism - Lombongo waterfall	10,773,072

[39] A detailed description of the estimation methods is provided in Appendix 1.

Trade-off scenarios:

We developed a series of eight alternative scenarios based on the plausible combinations of commodities that can be cultivated by any given farmer depending on his/her location in Bone Bolango District (e.g., in Pinogu Sub-District, a farmer can cultivate coffee and/or corn but cannot harvest sugar palm sap, because there are no palm sugar trees in the sub-district). In each scenario, we subtracted the estimated value of the economic benefits of forest-based activities from the estimated value of the agricultural activities to estimate the potential profit or loss to farmers from keeping forests standing. For purposes of the analysis, in order to estimate the cost of forest-boosting interventions from the perspective of local farmers, we assume that the agricultural commodities (coffee and corn) would replace the forest-based activities, rather than both being carried out simultaneously. The scenarios are described below:

Coffee	
Scenario 1a:	Ground coffee (10g) vs NTFPs (rattan) and tourism
Scenario 1b:	Ground coffee (100g) vs NTFPs (rattan) and tourism
Scenario 1c:	Coffee (median value) vs NTFPs (rattan) and tourism
Corn	
Scenario 2a:	Corn (dried kernels) vs NTFPs (rattan and palm sugar) and tourism
Scenario 2b:	Corn (dried kernels) vs NTFPs (rattan) and tourism
Coffee and Corn	
Scenario 3a:	Ground coffee (10g) and corn (dried kernels) vs NTFPs (rattan) and tourism
Scenario 3b:	Ground coffee (100g) and corn (dried kernels) vs NTFPs (rattan) and tourism
Scenario 3c:	Coffee (median value) and corn (dried kernels) vs NTFPs (rattan) and tourism

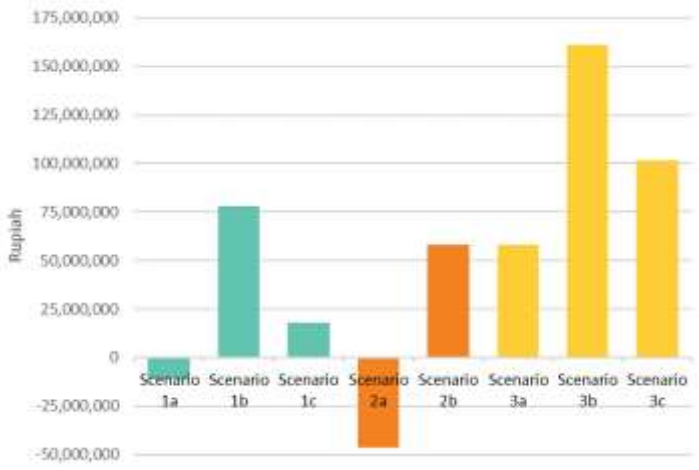

Figure 18. *The opportunity cost of forest conservation under alternative plausible commodity production scenarios in Bone Bolango District*

The potential forgone profits from coffee and corn cultivation associated with forest conservation are variable and highly dependent on the type of product processed from raw coffee. Nevertheless, the analysis indicates that there are significant economic and indirect values in the standing forest, and that some forest conversion does not appear to increase economic welfare. Notably, sales of 10g bags of ground coffee (Scenarios 1a and 2a yield negative profits) appear to be a poor economic choice for farmers in the region and do not justify additional forest clearing. In contrast, corn cultivation is generally more profitable. The sale of 10g bags of ground coffee is usually only based on demand and is not common. Furthermore, palm sugar extraction and processing yield high profits, which explains why standing forests are more lucrative than some of the cultivated coffee products. Considering the high value of palm sugar and the potential sugar palm expansion program in the future, there exists a threat of forest conversion to sugar palm monoculture plantations. Additionally, the combined value of ecosystem services is far greater than that of even the most lucrative commodity cultivation scenario. Together, these results point to the need for initiatives and incentives to strengthen the value of forest-based activities to counter the potential for corn crops to expand into forested areas.

7 Recommendations

Bone Bolango District has many challenges and opportunities to protect its vast areas of forests and simultaneously support its economy. While forests in the district provide multiple direct economic benefits mainly to local communities, they also provide a range of ecosystem benefits that go beyond the local level, including disaster management and biodiversity habitat. Interventions to increase the economic benefits of standing forests need to be introduced and strengthened, and land-based sectors and economic activities need to be supported in a way that ensures that forests are protected. In other words, the economic value of lands with standing forests needs to be increased to offset the economic value of lands where the forests are cleared, and the economic value of existing agricultural lands needs to be increased to prevent expansion into forests and to increase the welfare of farmers. Heavy promotion of coffee and palm sugar by the district government may drive up expansion of these crops onto forested lands. Adequate support and safeguards are needed to ensure that production of the two commodities can be increased to meet the target demand without compromising forests.

The analyses of value chain bottlenecks and trade-offs among alternative activities carried out in this study and described in this report yield a set of recommendations for simultaneously improving production of the focus commodities and protecting forests in the district. The recommendations are classified by target audience, as follows:

- For the District Government of Bone Bolango (lead agency: Agriculture Agency):

Disincentives, such as halting the provision of seedlings and fertilizer and other assistance, for the cultivation of commodities which pose a threat to the forest, like corn, are already in place. However, this program is not effectively implemented due to a lack of resources to do the data verification. Currently, some farmers who grow corn in forest areas or steep slopes, still receive support with seeds and fertilizers. In order to support the implementation of this program, a reliable farmer registration system needs to be developed. Farmers need to register all their lands in the system to get support from

the government. This will help the government to allocate support to eligible farmers only. Mapping of stakeholders and locations for traceability is also needed to further design the interventions.

In the case of corn farming, farmers are also reluctant to switch from corn farming due to a lack of alternative livelihood options. Therefore, incentives (i.e., technical and financial support) could be directed towards providing support for alternative, more forest-friendly, livelihood options, including support for planting economically valuable forest trees and increasing the values and economic benefits of standing forests by providing technical assistance and necessary processing equipment and facilities to improve downline production of non-timber forest products.

Considering the lack of fertilizer use in the cultivation processes experienced across the focus commodities, the use of organic fertilizers could be one of the potential solutions. However, the local production of organic fertilizers has been limited due to the general preference to use the chemical fertilizers by farmers, despite the easy access to resources and materials that farmers have to produce their own organic fertilizers and the high price of chemical fertilizers. Technical assistance on the production and use of organic fertilizers are needed.

Many farmers need more than a brief training. They need long-term assistance because there are many issues in the field that cannot be carried out in just a few days of training. The government needs to provide a long-term technical support for intensification to boost coffee production without expanding the land. This could be carried out by strengthening the capacity of village extension workers to provide long term assistance training on sustainable agriculture to farmers.

In order to provide funds to increase sustainable agriculture productions, the government needs to find alternative investments. An online reliable agriculture database and monitoring system can be used for reliable district sustainability reports that can potentially attract investments. Bone Bolango District also needs to develop its investment potentials to help future investors identify the district's potential.

- For the District Government of Bone Bolango (lead agency: Industry, Trade, Cooperatives and SMEs Agency):

Farmers generally only focus on agricultural production and do not have the ability and time to develop their business. To address this issue, the government can facilitate the establishment and/or strengthening of farmer enterprises, such as farmer cooperatives and farmer groups to grow their business. Moreover, the government can facilitate the establishment and/or strengthening of BUMDes (village-owned enterprises) and strengthen their financial system to address farmers' heavy financial reliance on traders (*ijon*) who can provide them a loan.

Currently, the Society for Geographic Indications of Pinogu Robusta Coffee Bone Bolango still has limited resources to reach all actors in the district. Strengthen the capacity of this society to reach all actors in the Pinogu Coffee supply chain who cannot be reached by this group now can address this issue.

Supporting the derivative products of non-timber forest products is an alternative to increase the value of standing forests. Sugar palm is one of the main products from forests in Bone Bolango that is mostly sold in the form of brick sugar. Producing granulated palm sugar can increase profits since it has a

higher value. Some extra efforts need to be undertaken since previous efforts were not too successful, including finding the market and enhancing the quality of the product.

To reduce the amount of wood harvested from forests for cooking palm sap into palm sugar, the National Park Office had tried to provide rocket stoves that are, by far, more fuel efficient compared to conventional stoves, to some farmers in Bulango Selatan Sub-District. This effort should be replicated in other sub-districts to halt deforestation. Another alternative that can be tried is to plant fast-growing wood trees, so that they can be used as fuel for palm sap processing.

- For National Park Authority (Balai TNBNW SPTN Wilayah I Limboto):

Support for promoting and strengthening ecotourism by targeting the local communities living around the forests as the main actor that operates the tourism activity is another way to increase the value of standing forests, providing economic benefits to local communities, among others. In order to do so, BUMDes (village-owned enterprises) or cooperatives can be a key tool that allows local communities to develop ecotourism.

Strengthening ecotourism can also be done by integrating sustainable farming, such as organic coffee farming that has been implemented in villages in Pinogu. Under this arrangement, the farmers can focus on developing good agricultural practices, while BUMDes can promote the tourism element by providing a tour guide in the Nani Bogani Wartabone National Park to reach the villages equipped with lodging and meals to the visitors.

- The Society for Geographic Indications of Pinogu Robusta Coffee Bone Bolango:

There are some coffee products that are not bringing profits to farmers, therefore, there is an urgency to promote coffee products that generate more profits for farmers by analyzing the different production costs, profits and market of different coffee products. This study provides an in-depth analysis of coffee production costs incurred by farmers for reference. There is also a need to increase outreach to all actors in the Pinogu Coffee supply chain and increase their knowledge and capacity to produce coffee according to the geographic indication standards.

In order to increase the livelihood of Pinogu farmers in the sub-district, MIG-KRPBB should consider the inclusivity of other farmers in producing and marketing Pinogu coffee and train other farmers to meet the standards of producing the coffee according to the standards set in the certification.

8 Conclusion

The Bone Bolango District Head has pledged to make his district–at least 70% of whose land area is a conservation and protection area–a conservation district since 2017. Along with this commitment, ensuring that the district's development is carried out in accordance with best practices with the welfare of the community in mind may ensure the growth of its economy and its preservation of natural environment.

Sustainable agriculture is a key priority in Bone Bolango District because it employs a large number of people and contributes to the majority of the district's GDP. According to the findings from discussions with various parties in Bone Bolango District, there are a number of changes that can be introduced to promote sustainable agriculture and thus enhance the livelihood of the actors. In this study, coffee and corn are two focus agricultural commodities and palm sugar is the main non-timber forest products that plays an important role in the local livelihood in the district.

In the supply chain of coffee, a series of improvements could be made to boost the supply chain's economic value, such as increasing the distribution of high-quality seeds, building farmers' understanding and capacity to conduct cultivation practices to regenerate old and less productive coffee trees. Coffee producers in the district are also need a more proper equipment to process coffee beans more effectively and supports to distribute coffee products as the distribution expenses are very high because the coffee plantations are located far from the cities with limited road access. The profitability of coffee products varies depending on the type of coffee product. Selling 10g of ground coffee is a poor choice as study show that there is no profit to be made from this product. In contrast, 100g and 200g ground coffee and 200g roasted bean are the best options to sell coffee.

In the corn production value chain, there is still a need for more effective facilities to dry corn more optimally and production costs are still high because of labor-intensive practices. Drying is one of the crucial processes that can determine the selling price of corn, with traditional drying still widely applied today, the water content is higher and takes a longer time. Corn productivity also needs to be improved considering that the current average productivity in the district is still lower than the national average, which should focus on intensification rather than extensification that could reduce forest cover.

In the palm sugar production value chain, bottlenecks include an unfair pricing system set by some traders, difficulties to market to outside regions and limited processing facilities. An unfair pricing system occurs because many farmers are in debt to traders, both for their daily needs and for capital to make palm sugar. Modernized processing facilities must also be complemented by the skills of farmers and sufficient capital to use these facilities, which could be addressed by strengthening BUMDes (village-owned enterprises) that focus on palm sugar.

The opportunity cost of conserving forests is highly variable and dependent on the type of crops and their derivatives, as well as the forest-based economic activities that can currently be carried out in a given location. Overall, there are substantial economic and indirect values in the standing forest and some forest conversion does not appear to increase economic welfare. This points to a high potential for intervening to enhance forest values to favor forests.

Citation | Widiastomo, T, N Hapsari, CM Stickler. 2023. *Bone Bolango District: Building Resilient, Inclusive, Forested Jurisdictions in Indonesia*. San Francisco, USA: Earth Innovation Institute / Jakarta, Indonesia: Lingkar Temu Kapubaten Lestari. https://earthinnovation.org/Pub/23350/bone-bolango-district-building-resilient-inclusive-forested-jurisdictions-in-indonesia.

Appendix 1: Methodology for Calculating Opportunity Cost

The trade-off between forest preservation and agricultural production was estimated using opportunity cost calculation of net present value of foregone profits from agricultural production minus the benefits of forest conservation, using the formula below:

$$Opportunity\ cost = Net\ Present\ Value\ of\ forgone\ profits - Benefits\ of\ Forest\ Conservation$$

In the calculation of net present value of forgone benefits, as part of the opportunity cost calculation in this study, the forgone benefits refer to the benefits from alternative use of forests if they are cleared as opposed to protected. In this case, we focused on the use of cleared forest areas for agricultural production, where we calculated the profits from the production of the focus commodities (i.e. coffee and corn) based on the production costs and revenues for the respective crops.

The production costs were calculated using figures obtained through in-depth interviews with two farmers for each crop, which were selected based on the locations of their land areas to provide a comprehensive overview. These figures are expenses incurred by farmers and categorized into three categories: (1) inputs; (2) machines and equipment; and (3) labor. Inputs refer to tangible materials that need to be purchased regularly, mostly every planting cycle, and include seeds and seedlings, fertilizers, insecticides, pesticides, fuels (gas, electricity, etc.) for machines and equipment and packaging. Machines and equipment refer to tangible items that are purchased or rented and used to conduct production processes until the products are sold to the immediate buyers, including sprayers, land mowers, hoes, garden shears, containers, peelers, roasting machines, packing machines and transportation. Machines and equipment are different from inputs as they may not be purchased every planting cycle and have their own economic lifespans, usually multiple years, in which they have economic values. Labor costs refer to expenses incurred by farmers for employing workers to support the production, processing and sales of their products. As observed through interviews with several partners, many farmers were actively involved in the production and sales of their products and assisted by family members, where the work was not remunerated. However, to provide a more accurate assessment, two scenarios are provided in the calculation, where the labor costs of remunerating farmers and family members are included and excluded. In the first scenario, where the work done by farmers and family members is remunerated, the calculations were done using hours worked for each person and an hourly rate based on the rate that the farmers use for paying workers.

Table 26. *Production activities and items associated with the identified costs*

Production Phase	Activities/Items
Land preparation	Input: herbicide, insecticide, fuel (for operating land clearing machines) Machines/equipment: mower, tractor, sprayer, machete Labor: hiring workers
Planting	Input: seeds or seedlings, fertilizer and/or polybags (for seedling production) Machines/equipment: planter, hoe, sickle Labor: hiring workers
Cultivation	Input: fertilizer, pesticide, herbicide Machines/equipment: sprayer, sickle, shears Labor: hiring workers
Harvesting	Input: fuel (for operating harvester) Machines/equipment: harvester, container Labor: hiring workers
Processing	Input: fuel (for operating processing machines) Machines/equipment: peeler, huller, dryer, sheller, roaster, wok, drying mat, container Labor: hiring workers
Packaging	Input: pouch, label Machines/equipment: packer, weighing scale Labor: hiring workers
Transportation/distribution	Input: fuel (for operating vehicle) Machines/equipment: vehicle, transport fee Labor: hiring workers

Information on the revenues obtained by farmers from these economic activities were also gathered by interviewing farmers. Calculation on the revenue was done using figures on the frequency of harvesting per year, average production yield per harvesting, yield of end products that farmers were able to produce as well as sale prices of the products. The annual profits were then estimated by calculating the difference between the annual revenues and the production costs. These profits were then calculated in terms of Net Present Value (NPV), projecting the annual net income likely to be received by farmers from these forest-replacing economic activities for 30 years into the future with a discount rate of 5 percent.

The calculations of forgone profits, although do not account for short-term fluctuations, were calculated using a number of assumptions to provide conservative profit projections, using references obtained from desktop research and stakeholder interviews. General assumptions used for calculating the annual net profits of both coffee and corn production are as follows:

1. All trees and plants were planted at the same time
2. The agricultural practices throughout the production are conducted consistently

3. The revenues that the farmers are able to generate are the maximum amount of revenues, assuming that all of the products are sold
4. One working day consists of 8 hours of work
5. When figures were given in ranges, the upper limit of the range was used in the calculation
6. When farmers were unable to provide exact figures, figures were obtained from other farmers producing the same crop in the same district or from desktop studies, using official governmental data whenever possible
7. Unless information on the frequency of input (i.e. fertilizers, pesticides, herbicides) application was obtained through the interviews, it was assumed that farmers implemented such practices according to Good Agricultural Practices (GAP) guidelines published by the Ministry of Agriculture[40]
8. Unless information on the frequency of machine and equipment replacement was obtained through the interviews, the calculation of the costs associated with the replacement of machines and equipment was done using official governmental document[41] detailing economic lifespans of the respective machines and equipment

We applied the following assumptions to estimate the annual net profits from coffee production:

1. Coffee trees are planted at 3m x 4m spacing
2. All trees have reached their productive age after 3 years and will remain productive for 30 years
3. Eight kilograms of coffee cherries are needed to produce 1 kilogram of green beans, which can be processed into 800 grams of roasted beans or ground coffee.

We made the following assumption to estimate the annual net profits from corn production:

1. The weight of dried corn kernels (end product) is 39% of the weight of the harvested, unshelled and undried corn cobs[42]

To provide a comparable assessment of net present value of profits from agricultural production and benefits of forest conservation, the calculation for both values was done using a per-capita basis as opposed to the per-hectare basis. This is due to the vast forest areas in Bone Bolango District that may not be utilized equally due to the different levels of accessibility. In other words, forest edges may be utilized more and provide more benefits to communities where they can easily access them for harvesting food, non-timber forest products and establishing facilities for ecotourism, compared to forest interiors that are less accessible. However, it is worth noting that many indirect benefits of forest conservation, such as provision of good air quality and habitat for biodiversity, may be derived from the

[40] http://cybex.pertanian.go.id/mobile/artikel/58883/9-Teknik-Menyemprot-Tanaman-Padi-Yang-Baik-Dan-Benar/
[41] https://peraturan.bpk.go.id/Home/Details/121997/perbup-kab-banjar-no-4-tahun-2019
[42] http://bppgalur.blogspot.com/2017/02/konversi-padi-jagung-kedelai-kacang.html

entire forest areas, including forest edges and interiors, and the overall forest conservation can benefit not only communities living in close proximity to the forests but also a much wider range of population.

Value of agricultural production

Coffee

Based on the series of interviews conducted with farmers and relevant district-level agencies in Bone Bolango District, the average yearly production costs incurred along the value chains of coffee produced in Pinogu Sub-district, as well as the average yearly revenues, throughout the 30-year projection were acquired and presented in Table A1 and Table A2 below.

Table A1. *Costs associated with coffee production in Pinogu Sub-district, Bone Bolango District*

Activity	Average Yearly Production Costs (IDR)			
	Input	Machines and Equipment	Labor (if work of farmers and their family members is remunerated)	Labor (actual costs)
Land preparation	-	5,060,000	10,050,000	6,700,000
Pre-planting	1,250,000	3,000,000	1,400,000	-
Planting	-	793,000	2,580,000	2,025,000
Post-planting	-	65,000	-	-
Cultivation	4,480,000	1,010,000	24,850,000	13,710,000
Pre-harvesting	-	-	-	-
Harvesting	-	122,000	20,850,000	9,410,000
Post-harvesting	562,500	1,300,000	15,150,000	7,800,000
Processing	385,000 (RB)	2,975,000 (GB) 3,520,000 (RB) 6,610,000 (GC)	1,200,000 (GB) 3,415,000 (RB) 1,725,000 (GC)	6,250,000 (RB)
Packaging	675,000 (GB 1 kg) 125,000 (GB 50 kg) 180,000,000 (GC 10 g) 33,000,000 (GC 50 g) 10,615,000 (GC 100 g) 4,078,500 (GC 200 g) 3,792,000 (RB 200 g) 2,216,000 (RB 500 g) 1,392,000 (RB 1 kg)	1,265,000 (GC 100 g) 665,000 (GC 200 g) 665,000 (RB 200 g) 305,000 (RB 500 g) 185,000 (RB 1 kg)	625,000 (GB) 340,000 (RB 200 g) 136,000 (RB 500 g) 68,000 (RB 1 kg) 680,000 (GC 100 g) 340,000 (GC 200 g)	-
Transportation/ distribution	-	3,375,000 (GB) 2,250,000 (RB) 2,625,000 (GC)	-	-
Sales/marketing	-	-	-	-

GB = green beans; RB = roasted beans; GC = ground coffee

Table A2. *Average yearly revenue for coffee farmer in Pinogu Sub-district, Bone Bolango District*

Product	Price	Average Yearly Revenue	
		Revenue per hectare	Revenue per capita
Green beans	20,000-35,000/kg	4,900,000-7,800,000	3,675,000-5,830,000
Roasted beans - 200 gr	30,000/200 gr	26,880,000	8,400,000
Roasted beans - 1 kg	90,000-120,000/kg	10,080,000-21,504,000	6,720,000-7,560,000
Ground coffee - 10 gr	1,000/10 gr	31,100,000	23,300,000
Ground coffee - 50 gr	4,500-5,000/50 gr	10,080,000-31,100,000	7,560,000-23,300,000
Ground coffee - 100 gr	9,000-26,000/100 gr	10,080,000-31,100,000	7,560,000-23,300,000
Ground coffee - 200 gr	18,000-35,000/200 gr	10,080,000-31,360,000	7,560,000-9,800,000

Coffee in Pinogu is produced into a variety of products that are priced differently, depending on the value-adding processes. Typically, coffee produced in Pinogu is sold as green beans, roasted beans or ground coffee. Depending on the market demand, these products are sold in different packages and often at different prices for the different packages.

The calculation, although conducted using the same methods, produced differing results. There are a number of factors contributing to the differences in the prices of coffee. In Pinogu, coffee is sold in many quality grades, which corresponds to the prices of the coffee. Different farmers also process their coffee into different products, depending on a number of factors such as market demands, farmers' capacities and available technology. Processing coffee beans into ground coffee could increase the value of the coffees at a ratio of around 82.13%[43], which is considered a high value-adding ratio[44]. However, the price rates of the coffee vary depending on the quality of the final product. Actors along the supply chain also play a role in determining the prices of the coffee, and, unlike corn, neither local nor national governments regulate the prices of Pinogu coffee.

In addition to sale prices, the revenues obtained by farmers from coffee production also depend on the total area of land owned by farmers that is planted with coffee trees. On average, the total land area for coffee trees owned by a farmer is 3 ha. As shown in Table A1, the calculation of farmers' revenues used a per-hectare basis to provide a comparable assessment between farmers, and a per-capita basis was used to provide a comparable assessment between the net present value of profits from coffee production and benefits of forest conservation.

Based on Table A1 and Table A2, the profits generated by coffee farmers in Pinogu Sub-District are as follows:

[43] Mooduto et al. 2021.
[44] Mooduto et al. 2021

Table A3. *Profits generated by interviewed coffee farmers in Pinogu Sub-District, Bone Bolango District*

Product	Average Yearly Profit			
	Profit per hectare (if family members work is remunerated)	Profit per hectare (if family members work is not remunerated)	Profit per capita (if family members work is remunerated)	Profit per capita (if family members work is not remunerated)
Green beans	(-15,824,944) - (-194,333)	(-874,944) - (-194,333)	(-11,868,708) - (-145,750)	(-656,208) - (-145,750)
Roasted beans - 200 gr	-12,372,737	11,159,795	-3,866,480	3,487,436
Roasted beans - 500 gr	-16,150,871	7,229,342	-5,047,147	2,259,169
Roasted beans - 1 kg	(-15,493,804) - 4,805,533	4,805,533 - 7,835,635	-4,841,813 - 3,604,150	2,448,636 - 3,604,150
Ground coffee - 10 gr	-50,365,611	-35,454,500	-37,774,208	-26,590,875
Ground coffee - 50 gr	(-6,118,697) - (3,583,266)	(-3,583,266) - 8,792,413	(-2,687,450) - (-4,589,023)	(-2,687,450) - 6,594,310
Ground coffee - 100 gr	(-587,833) - 6,467,155	2,481,533 - 30,253,555	(-440,875) - 2,020,986	1,861,150 - 10,742,458
Ground coffee - 200 gr	-8,564,737 - 38,395,333	14,967,795 - 38,395,333	(-2,676,480) - 2,879,650	2,879,650 - 4,677,436

The profits tabulated in Table A3 were projected into the next 30 years to obtain the Net Present Value, as tabulated below.

Table A4. *Net Present Value (NPV) of coffee production in Bone Bolango District*

	NPV			
Product	NPV per hectare (if family members work is remunerated)	NPV per hectare ((if family members work is not remunerated)	NPV per capita (if family members work is remunerated)	NPV per capita (if family members work is not remunerated)
Green beans	(-259,093,128) - (-3,181,713)	(-14,324,985) - (-3,181,713)	(-194,319,846) - (-2,386,285)	(-10,743,739) - (-2,386,285)
Roasted beans - 200 gr	(-202,572,043)	182,713,206	(-63,303,763)	57,097,876
Roasted beans - 500 gr	(-264,429,346)	118,362,051	(-82,634,170)	36,988,141
Roasted beans - 1 kg	(-253,671,554) - 78,678,359	78,678,359 - 128,288,559	(-79,272,360) - 59,008,769	40,090,174 - 59,008,769
Ground coffee - 10 gr	(-824,608,501)	(-580,477,065)	(-618,456,376)	(-435,357,799)
Ground coffee - 50 gr	(-100,178,076) - (-58,666,858)	(-58,666,858) - 143,953,361	(-75,133,557) - (-44,000,144)	(-44,000,144) - 107,965,021
Ground coffee - 100 gr	(-9,624,272) - 105,883,187	40,628,783 - 495,324,856	(-7,218,204) - 33,088,496	30,471,587 - 175,880,373
Ground coffee - 200 gr	(-140,225,749) - 62,862,571	62,862,571 - 245,059,499	(-43,820,546) - 47,146,929	47,146,929 - 76,581,093

Corn

Corn has been deemed as a lucrative crop. As described above, many farmers formerly planting other crops, such as coffee, have switched their trees to plant corn. However, many studies[45] have stated that corn production does not generate high enough income for farmers.

Based on the series of interviews conducted with farmers and relevant district-level agencies in Bone Bolango District, the average yearly production costs incurred along the value chains of corn produced in the district, as well as the average yearly revenues, throughout the 30-year projection were acquired and presented in Table A5 and Table A6 below.

Table A5. *Costs associated with corn production in Bone Bolango District*

Activity	Average Yearly Production Costs (IDR)			
	Input	Machines and Equipment	Labor (if work of farmers and their family members is remunerated)	Labor (if work of farmers and their family members is not remunerated)
Land preparation	3,761,000	3,500,000	8,820,000	-
Seed/seedling production/procurement	6,000,000	-	-	-
Planting	-	-	4,800,000	-
Post-planting	2,400,000	-	5,040,000	-
Cultivation	13,600,000	1,900,000	31,920,000	-
Pre-harvesting	-	30,000	1,680,000	-
Harvesting	-	1,000	5,400,000	-
Post-harvesting	-	-		-
Processing	-	2,225,000	4,200,000	-
Packaging	80,000	2,000,000	840,000	-
Transportation/ distribution	-	-	-	-
Sales/marketing	-	-	-	-
TOTAL	25,841,000	9,656,000	62,700,000	-

Table A6. *Average yearly revenue for corn farmer in Bone Bolango District*

Average Yearly Revenue (IDR)			
Product	Price per kg	Overall revenue per hectare	Overall revenue per capita
Dried corn kernels	4,800	21,600,000	10,800,000

[45] Murtisari, A. (2015). Pendapatan, Sumber dan Distribusi Pendapatan Rumah Tangga Petani Jagung di Kabupaten Bone Bolango. Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah, 2(3), 129-134.

The prices of corn vary depending on the water content. According to the District Agency for Agriculture and Livestock, the prices of corn, sourced from traders, with a water content between 15-17% are around IDR4,900-IDR4,950 per kilogram, whereas corn with a water content between 18-30% are around IDR4,750-IDR4,850 per kilogram. If sourced from exporters, the price of corn with a water content between 15-17% is around IDR5,000 per kilogram, whereas corn with a water content between 18-30% is IDR4,950 per kilogram. As mentioned above, the prices of corn are regulated by the national government to maintain price stability, ensuring that farmers receive fair share of profits and consumers do not overpay.

Based on Table A5 and Table A6, the profits generated by corn farmers in Bone Bolango District are as follows:

Table A7. *Profits generated by interviewed corn farmers in Bone Bolango District*

Average Yearly Profit				
Product	**Average yearly profit per hectare (if family members work is remunerated)**	**Average yearly profit per hectare (if family members work is not remunerated)**	**Average yearly profit per capita (if family members work is remunerated)**	**Average yearly profit per capita (if family members work is not remunerated)**
Dried corn kernels	(-26,846,683)	10,189,983	(-13,423,342)	5,094,992

The profits tabulated in Table A7 were projected into the next 30 years to obtain the Net Present Value, as tabulated below.

Table A8. *Net Present Value (NPV) of corn production in Bone Bolango District*

Average Yearly Profit				
Product	**Average yearly profit per hectare (if family members work is remunerated)**	**Average yearly profit per hectare ((if family members work is not remunerated)**	**Average yearly profit per capita (if family members work is remunerated)**	**Average yearly profit per capita (if family members work is not remunerated)**
Dried corn kernels	(-439,546,008)	166,835,003	(-219,773,004)	83,417,502

Benefits of Forest Conservation-based Activities

Table A9. *Types of ecosystem services included to calculate forest conservation benefits*

Ecosystem services	Benefit	Beneficiary	Type of economic benefit
Water regulation	Irrigation water	Farmers	Indirect
Non-timber forest products	Rattan, sago, honey, gaharu, bamboo, etc. Food e.g. crops, fruit, fish	People living near the forest	Direct
Air quality regulating	Good quality air	Everyone	Indirect
Disaster mitigation	Flood control	People living in flood-prone areas	Indirect
	Landslide prevention	People living in landslide-prone areas	Indirect
	Fire prevention	People living in fire-prone areas	Indirect
Biodiversity	Protecting rare and endangered species	Everyone	Indirect
Carbon sequestration and storage	Climate regulation	Everyone	Indirect
Tourism and recreation	Recreational hiking and camping	Hikers, campers	Direct

Estimation of economic value of each forest ecosystem services

1. Water regulation

The total forest area in Bone Bolango is 132,428 ha. If the price IDR 4 million/ha/year[46] applied, the total benefit from forest conservation for water regulation in Bone Bolango is IDR 529.71 billion.

2. Air quality
    a. O_2 generation

Previous studies show that the mean O_2 generation per unit of forest, lawn, and water areas is 109.53 ton/ha, 46.18 ton/ha, and 0.17 ton/ha, respectively. The cost of producing O_2 through industrial processes was used in this study to estimate the benefit of O_2 generation at a value of IDR 879,810/ton.

    b. Air temperature amelioration

[46] Budhi, Gelar Satya, S. A. Kuswanto, and M. Iqbal. "Concept and implementation of PES program in the Cidanau watershed: a lesson learned for future environmental policy." Analisis Kebijakan Pertanian 6.1 (2008): 37-55.

Average annual evaporation per unit water is 927.1 mm. Based on the water area in parks, the overall evaporation of water bodies can be obtained. The ecological service value of evaporative cooling was calculated as IDR 283.74 per unit. The transpiration amount for forest and grass areas is 22.61 × 106KJ/ha and 11.75 × 106KJ/ha, respectively. With the residential electricity price at IDR 1,444.70/kwh, transpiration cooling can be valued.

c. SO2 removal

The SO_2 removal per unit forest area was based on the average amounts per broad-leaved and coniferous tree, with a value of 152.13kg/ha. For the land cover type of lawn, the value is 279.03 kg/ha. As aquatic plants absorb only a small amount of sulfur oxides from the atmosphere, the ecological service of SO_2 removal by water was neglected in this study. According to the literature, the marginal cost of SO_2 in China is IDR 6,600/kg.

d. NOx removal

Previous studies have indicated that NO_x removal per unit of forest and unit of grassland is 380 kg/ha and 6 kg/ha, respectively. The benefit of NO_x removal in water bodies can be neglected. The vehicle exhaust denitrification treatment cost was used in calculating the ecological service value of NO_x removal, with a value of IDR 35 million/ton.

3. Disaster mitigation: flood
   a. Number of buildings

Initially, the building data that will be used to calculate the number of buildings that are located within the disaster-prone area is sourced from OpenStreetMap (OSM) data. But, due to incomplete data, the settlement area by BRG and existing data by OSM is used to calculate the average number of buildings in a hectare of the settlement area. In Bone Bolango, the building density is 18 buildings per hectare. We estimated just over 11,000 buildings to be under some type of flood risk (Table A10).

Table A10. *Estimate of the number of buildings in flood risk zones in Bone Bolango District*

Risk level	Settlement area	Total buildings
None	3,413	61,436
Low	161	2,890
Moderate	413	7,426
High	41	760

b. Building damage rate
   - Low: no damage;
   - Moderate: 50% of the number of houses affected by light damage multiplied by the regional price unit;
   - High: 50% of the number of houses affected by moderate damage multiplied by the regional price unit, and 50% of the number of houses affected by heavy damage multiplied by the regional price unit.

c. Economic benefit
   - Moderate= $\frac{1}{2} \times 7{,}426 \times \frac{1}{4} \times IDR\ 180{,}000{,}000 = 167{,}085{,}000{,}000$
   - High $\left(\frac{1}{2} \times 760 \times \frac{1}{2} \times IDR\ 180{,}000{,}000\right) + \left(\frac{1}{2} \times 760 \times IDR\ 180{,}000{,}000\right)$

$= IDR\ 34{,}200{,}000{,}000 + IDR\ 68{,}400{,}000{,}000 = IDR\ 102{,}600{,}000{,}000$

   - Total $= IDR\ 167{,}085{,}000{,}000 + IDR\ 102{,}600{,}000{,}000 = IDR\ 269{,}685{,}000{,}000$

4. Disaster mitigation: landslide
   a. Number of buildings

Table A11. *Estimate of the number of buildings in landslide risk zones in Bone Bolango District*

Risk level	Settlement area (ha)	Total buildings
None	3,834	69,005
Low	177	3,180
Moderate	16	291
High	2	37

b. Building damage rate
   - Low: no damage;
   - Moderate: 50% of the number of houses affected by light damage multiplied by the regional price unit;
   - High: 50% of the number of houses affected by moderate damage multiplied by the regional price unit, and 50% of the number of houses affected by heavy damage multiplied by the regional price unit.

c. Economic benefit
   - Moderate= $\frac{1}{2} \times 291 \times \frac{1}{4} \times IDR\ 180{,}000{,}000 = 6{,}547{,}500{,}000$
   - High= $\left(\frac{1}{2} \times 37 \times \frac{1}{2} \times IDR\ 180{,}000{,}000\right) + \left(\frac{1}{2} \times 37 \times IDR\ 180{,}000{,}000\right)$

$= IDR\ 1{,}665{,}000{,}000 + IDR\ 3{,}330{,}000{,}000 = IDR\ 3{,}995{,}000{,}000$

- Total= $IDR\ 6{,}547{,}500{,}000 + IDR\ 3{,}995{,}000{,}000 = IDR\ 10{,}542{,}500{,}000$

5. Disaster mitigation: forest and land fire
    a. Number of buildings

Table A12. *Estimate of the number of buildings in forest and land fire risk zones*

Hazard level	Settlement area	Total buildings
None	4,025	72,446
Low	0	5
Moderate	1	21
High	2	40

    b. Building damage rate
        - Low: no damage;
        - Moderate: 50% of the number of houses affected by light damage multiplied by the regional price unit;
        - High: 50% of the number of houses affected by moderate damage multiplied by the regional price unit, and 50% of the number of houses affected by heavy damage multiplied by the regional price unit.

    c. Economic benefit
        - Moderate= $\frac{1}{2} \times 21 \times \frac{1}{4} \times IDR\ 180{,}000{,}000 = 472{,}500{,}000$
        - High= $\left(\frac{1}{2} \times 40 \times \frac{1}{2} \times IDR\ 180{,}000{,}000\right) + \left(\frac{1}{2} \times 40 \times IDR\ 180{,}000{,}000\right)$

$= IDR\ 1{,}800{,}000{,}000 + IDR\ 3{,}600{,}000{,}000 = IDR\ 5{,}400{,}000{,}000$

- Total= $IDR\ 472{,}500{,}000 + IDR\ 5{,}400{,}000{,}000 = IDR\ 5{,}872{,}500{,}000$

6. Biodiversity
    a. Identification of rare and endangered species
        1. Anoa (*Bubalus depressicornis*)

The lowland anoa (*Bubalus depressicornis*) has most recently been assessed for The IUCN Red List of Threatened Species in 2014. *Bubalus depressicornis* is listed as Endangered under criteria C1+2a(i).

2. Maleo Senkawor (*Macrocephalon maleo*)

The maleo (*Macrocephalon maleo*) has most recently been assessed for The IUCN Red List of Threatened Species in 2021. *Macrocephalon maleo* is listed as Critically Endangered under criteria A2cd+4cd.

3. Mandar muka-biru (*Gymnocrex rosenbergii*)

The blue-faced rail (*Gymnocrex rosenbergii*) has most recently been assessed for The IUCN Red List of Threatened Species in 2016. *Gymnocrex rosenbergii* is listed as Vulnerable under criteria C2a(i).

b. Estimation of offsite protection cost of rare and endangered species

1. Labor cost

IDR 2.800.850 per month

IDR 4.763.431.417 per km2

2. Land lease cost

IDR 1.200.179.569 per km2

3. Forest pest control chemicals

75,000.00 g/km2

IDR 13.205 per gram

IDR 990.375.000 per km2

4. Chemicals for disease and pest control in grassland

180 g/km2

IDR 86.437 per gram

IDR 15.558.660 per km2

5. Agricultural irrigation cost

IDR 36.019.925 per km2

Trees: IDR 180.099.625 per km2

Herbs: IDR 288.159.400 per km2

Total cost = IDR 6.448.419.046 per km2

c. Habitat analysis and cost estimation

Table A13. *Estimate of the offsite protection costs of rare and endangered species*

Land use	Elevation	Slope	Distance to river	Distance to settlement	Area (km2)	Cost (IDR)
Primary forest	0-1000m	9-25%	800-1000 m	6-8 km	25.51	164.5 B

7. Carbon sequestration and storage

a. Aboveground biomass (AGB)

The estimation of aboveground biomass (AGB) is carried out by implementing the mean AGB that has been carried out by the Ministry of Environment and Forestry by collecting data from surveys conducted on each forest type in Indonesia. In Sulawesi Island, at least 433 measurement plots have been carried out, which results in the mean AGB for primary dryland forest and secondary dryland forest being 275.2 t/ha and 206.5 t/ha, respectively.

b. Biomass conversion to carbon

To estimate the amount of carbon (C) in each forest type, information on carbon fraction is needed. The carbon fraction of biomass (dry weight) was assumed to be 47% (1-ton biomass = 0.47 tons C) following IPCC 2006 Guideline.

Table A14. Estimate of the economic value of forest carbon storage in Bone Bolango

Forest area 2019 (ha)	Mean AGB (t/ha)	Total AGB (t)	Total C (t)	Carbon storage economic value (USD)
Primary: 93,426	275.2	25,710,835	12,084,093	120,840,930
Secondary: 39,002	206.5	8,053,913	3,785,339	37,853,390
Total		33,764,748	15,869,432	158,694,320

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