

Prioritization and feasibility analysis of non-timber forest products for green economy development in Papua Province, Indonesia

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Abstract. Ap AT, Wahyudi, Hendri, Allo AG, Warsito AP. 2026. *Prioritization and feasibility analysis of non-timber forest products for green economy development in Papua Province, Indonesia.* *Asian J Ethnobiol* 9: y090103. <https://doi.org/10.13057/asianjethnobiol/y090103>. The utilization of Non-Timber Forest Products (NTFPs) is one option for green economy development in Papua Province due to their sustainability on forest ecosystem, low emissions and livelihood suitability of local communities. This research is aimed to identify NTFPs inside forest, investigate the processes of making raw materials into semi-finished and finished products, and select priority commodities for green economy development using Benefit and Cost Analysis. Data were collected from field survey and focus group discussions at twelve locations involving 112 respondents. Results indicate that 61 NTFPs inside forest are identified with seven NTFPs are developed into semi-processed commodities, three processed commodities, and 48 finished commodities. Eight finished NTFPs are prioritized for green economic commodities, including sago products, cacao powder, coffee powder, eucalyptus oil, honey, ant nest tea, agarwood leaf tea, and eco prints. Feasibility analysis shows that high priority NTFP commodities include eco prints, ant nest tea and coffee powder with B/C Ratio of 3.94, 2.56, and 1.53, respectively, while sago products have medium priority with B/C Ratio of 1.18, and the rests have low priority due to B/C ratio <1.0. Average score based on green economy variables is 82% with the highest value (94%) for eco prints followed by sago products (90%), attaining ecological benefits, added values and challenges. Ant nest tea and coffee powder with average of 87% fulfil variables related to community direct involvement, extra incomes and works, and environmental values. The findings of this study recommend that the four NTFPs (i.e. eco prints, ant nest tea, coffee powder and sago products) could be nominated for green economy development in Papua Province.

Keywords: Communities, feasible analysis, green economy, non-timber forest products, Papua Province

INTRODUCTION

Papua Province (Indonesia) has abundant forest resources, from timber and non-timber forest products to various ecosystem services. More than a decade, forest utilization in Papua is oriented toward timber extraction, resulting in negative impacts on forest ecosystems (Katherina et al. 2023), interrupting livelihood of local community (Jimoh et al. 2013), declining tropical forest biodiversity (Wahyudi et al. 2022), and contributing to carbon emissions and climate change (Kraxner et al. 2015). Recently, the Indonesian government shifts the paradigm of forest policies and management from timber extraction to non-timber forest products and forest ecosystem services (Pasaribu et al. 2021). These policies are applied to optimize Non-Timber Forest Products (NTFPs) roles for forest ecosystems (Latifah et al. 2023), acknowledge local communities to improve the livelihood and social-economy contributions of forest (Aldieri and Vinci 2018), reduce carbon emissions (D'Amato et al. 2020), and implement the National Determined Contribution (NDC) of Indonesia under Forest and Other Land Used (FOLU) net sink 2030 strategy (Akhtar 2023; Hastuti 2024).

The majority of indigenous communities in Papua live in or adjacent to their customary forests (Ungirwalu et al. 2021), and heavily depend on their forest resources to fulfil their daily livelihood needs (Sawaki et al. 2022). These forests provide various NTFPs in the forms of fresh and healthy vegetables, fruits, staple foods, essential nutrients and vitamins, traditional medicine, and energy (Wahyudi et al. 2024). In addition, the NTFPs serve as lifetime savings for local communities mainly during uttermost seasons of schooling or tuition periods, Christmas and new year eve celebration and other cultural events (Runtuboi et al. 2023; Ungirwalu et al. 2023). Harvesting and trading NTFPs offer various advantages to local communities, ranging from extra incomes, informal jobs, alternative works when local communities could not go for fishing due to high tide seasons, and fulfillment of community's subsistence needs (Rahawarin 2017).

Nowadays, trading and utilizing NTFPs in Papua Province are mostly in the forms of fresh, unprocessed, raw material, whole parts, or semi-processed products sold mostly at the local markets (Ap et al. 2023). Under these conditions, NTFPs could not provide optimum contributions and added values for social, economy and environment (Runtuboi et al. 2023). Converting raw

materials into semi-processed and finished NTFPs through down streaming, for examples, will offer multiple impacts, not only increasing social and economic values but also sustaining local resources and environment (Ap et al. 2025). This strategy is in line to green economy development principle, which is new direction and development policy for Papua and West Papua Provinces as officially pledged in the Manokwari Declaration (Cámara-Leret et al. 2019).

Green economy is an economic activity from production, distribution and consumption intended to minimize risk to the environment (Nandy et al. 2022), reduce impact of ecological degradations and pollutions (Aldieri and Vinci 2018), produce eco-friendly products (Puspita et al. 2024), develop resources-saving technology to reduce emissions and to mitigate climate change (Masdar et al. 2022), and contribute directly to the local communities (Hendri et al. 2023). It is in contrast to the conventional economy heavily focusing on profitability and resources exploitation which contribute to pollutions, carbon emission, and less concerned to prosperity of local communities (D'Amato et al. 2020).

Research on the theme of NTFPs in Papua Province have been conducted by many researchers, mainly focused on NTFPs identification (Pasaribu et al. 2021; Ungirwalu et al. 2023), and traditional utilizations and diversity of NTFPs (Cabuy et al. 2012; Ondikeleuw et al. 2020; Wahyudi et al. 2022). However, research concerning the idea of down streaming or developing finished NTFPs with economic feasibility analysis for green economy development in Papua Province is absent. Therefore, this research is aimed to (i) identify and record NTFPs harvested and utilized inside forest at eleven research locations across Papua Province, (ii) determine semi-processed, processed and finished NTFPs, and select eight finished NTFPs for green economy commodities, and (iii) do feasibility analysis of the eight finished NTFPs for green economy commodity using B/C ratio values. The results of this study are expected to be used as reference

and scientific evidences in designing and developing forest resources policy for green economy based on NTFPs with local contents in Papua Province and others.

MATERIALS AND METHODS

Study area

Data collection was conducted at twelve locations across Papua Province, Indonesia including seven Forest Management Units (FMUs), four Forest and Environmental Services Branch offices (FESBs), and forestry gallery (Figure 1). These eleven research locations represent diverse topography and altitudes ranging from coastal to highland areas. Seven FMUs are Jayapura City (JC), Sarmi (S), Keerom (K), Lintas Sarmi Mamberamo (SM), Biak Numfor (NF), Yapen (Y) and Waropen (W), while four FESBs were Jayapura (J), Sarmi (S), Keerom (K), and Mamberamo Raya (MR). Forestry gallery is located in Abepura, Jayapura City.

Data collection

Field surveys were conducted to visit and collect data from each research sites by visiting customary forests managed by local community. Intensive interviews using prepared questionnaires were used to collect data involving 10 respondents for each location, consisting of two officials, five local people, and three key respondents representing cultural leaders and two women. Total respondents were 110 from eleven research sites, and further two respondents were interviewed from the forestry gallery. Focus group discussion was also conducted at Jayapura City facilitated by Forestry Office of Papua Province with involvement from several national and international non-government organizations, university representative, and head officers of the eleven research locations.

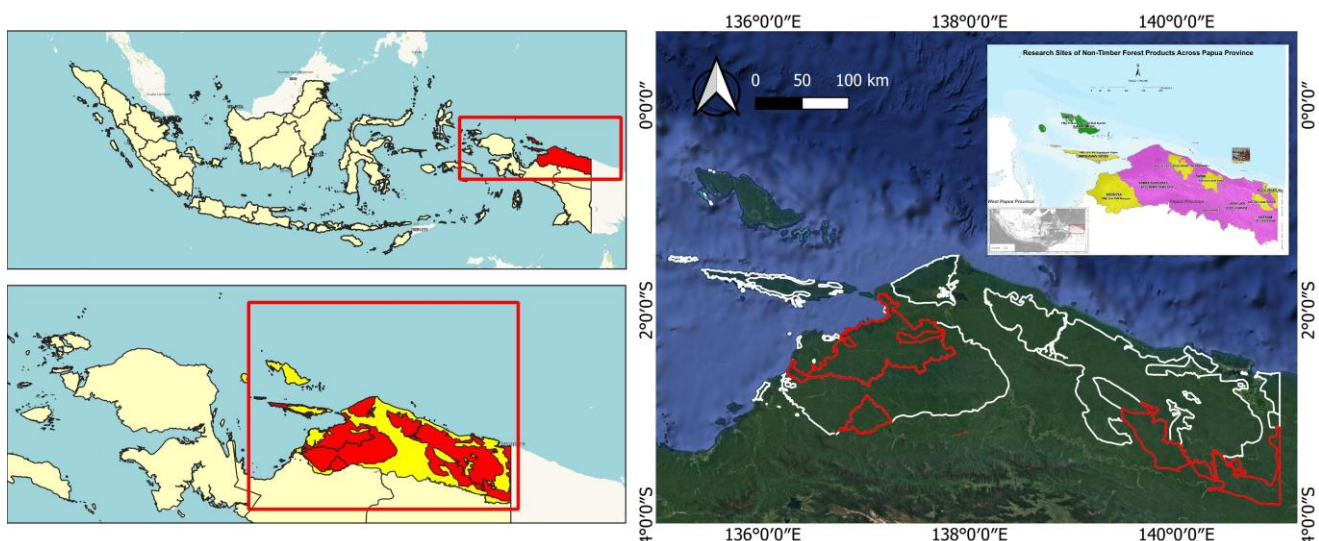


Figure 1. Research sites of non-timber forest products across Papua Province, Indonesia

Research framework

Research framework was developed for gap analysis of NTFPs inside forest, existing stage, optimum stage, and intervention outside forest to achieve research goals and outputs. This framework has five hierarchical stages from inside forest/research sites, existing stage, intervention I, optimum stage, forestry gallery, intervention II, and eight candidates for green economy commodities, as illustrated in Figure 2.

Research framework (Figure 2) shows that data collection consisted of seven steps beginning from raw material gathered inside forest into additional processes into recommended NTFP commodities for green economy. Initially, NTFPs inside forest were identified and recorded, covering the diversity, harvesting methods, and utilization at research sites (1). Local or Indonesian, English and botanical names NTFPs were recorded from eleven research locations and tabulated. Information regarding the advantages of NTFPs compared to timber products were detailed and listed on the box as existing stage (2). Intervention I is needed to add values of NTFPs through advanced processes using green economy principles (3), followed by optimization into semi-processed and processed NTFPs to enhance the added values as listed in the box of optimum stages (4). Finished NTFPs collected from the eleven research locations displayed and sold at the forestry gallery in Jayapura City were determined and tabulated, and designed for green economy development

from NTFPs based in Papua Province (5). Then, selections and nominations were conducted to obtain eight candidates of finished NTFPs for green economy and subsequently mapped with green economy variables, and feasibility analysis was employed using B/C ratio values, and these are classified for intervention II (6). Finally, green economy commodities were clustered into three levels of feasibility for high, medium and low (7). Selections to obtain eight finished NTFPs were conducted through focus group discussion involving two key respondents, shop clerk and manager of forestry gallery shop, Abepura Jayapura City. Selling records, customer preferences and local contents were variables used for the selections.

Selected eight finished NTFPs were tabulated on simple matrix to analyze its feasibility regarding green economy variables using several criteria and indicators. Check lists were used to mark the products that are fitted to the indicators. Green economy has four variables, i.e. economic potential, ecological benefits, added values, and challenges. Variable of economic potential has criteria: (i) material originality, with three indicators of endemic, planted and typical Papua, (iii) gained skill of local communities, with three indicators of training, workshop, and government program, (iii) local technology content, with five indicators of drying, roasting, packaging, grinding and pounding, (iv) market, with four indicators of local, regional, national and international.

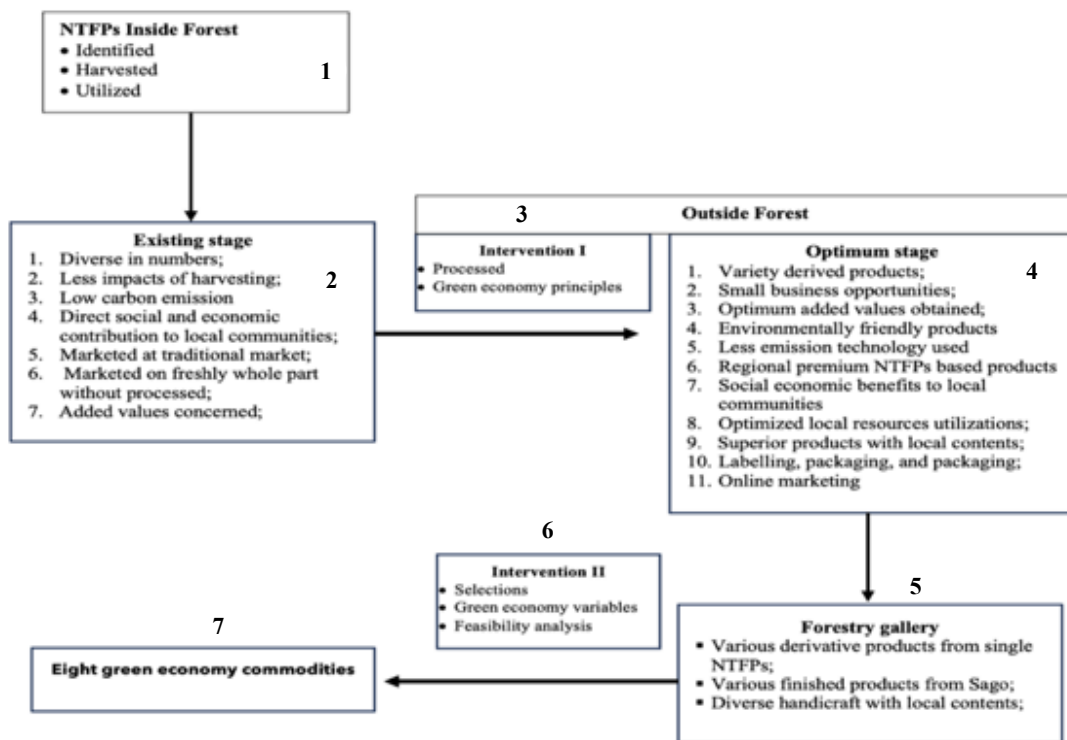


Figure 2. Research framework of feasibility analysis of NTFPs for green economy development in Papua Province, Indonesia

Second variable of green economy is ecological benefits, consisting of three criteria: (i) community direct involvement, with four indicators of planting, harvesting, drying and processing, (ii) small business creativities, with three indicators of informal works, extra incomes and home industry, (iii) environmental values, with four indicators of no pollution, low emission, labor intensive, and simple technology. Third green economy variable is added values, consisting of three indicators, i.e. branding and labelling, legal permits, and packaging. Fourth variable for green economy is challenges, which has two indicators of competitor and sustained market supply. There are 31 indicators in total used. Green economy values, expressed in percent (%), was calculated as $= (Gid / Ti) \times 100$, where *Gid* is green indicators of products and *Ti* is total indicators.

Benefit-Cost Ratio Analysis (B/C ratio)

Economic feasibility of the selected eight finished NTFPs was calculated using B/C ratio to evaluate the economic profitability. Ratio for B/C was calculated using the formula:

$$B/C \text{ ratio} = TR/TC,$$

Where TR is total revenue, and TC is total cost.

Decision criteria for B/C ratio is profitable, when B/C ratio > 1 , unprofitable B/C ratio < 1 , and B/C ratio = 1 is no-profit or profits are equal to the costs (break-even). Break Event Point (BEP) is economic tools or decisions to help business decide their minimum sale target to avoid losses and gain profits. It was calculated using the formula:

$$BEP = FC (1 AVC/TR),$$

Where FC is fixed costs, AVC for average variable costs, and TR is for total revenue.

The priority of green economy commodity was evaluated based on B/C ratio values, where B/C ratio < 1.0 is low priority, medium priority having B/C ratio 1.00 - 1.5, and high priority with B/C ratio > 1.5 . Finally (Stage 7, Figure 2), eight green economy commodities were ranked and proposed as green economy development in Papua Province clustered into highly, medium and low feasible.

RESULTS AND DISCUSSION

NTFPs inside forest

NTFPs inside forest from eleven research locations (consisted of seven FMUs and four FEBs) throughout Papua Province are very diverse across the locations. These NTFPs include biological materials, flora and fauna, and their byproducts or parts harvested, consumed and traded by local communities. Summary of the NTFPs identified, harvested and utilized by local peoples recorded from eleven research locations across Papua Province are tabulated in Table 1.

Table 1 reveals that there are 61 NTFPs identified and harvested from eleven research locations across Papua Province, and the numbers amongst research locations vary. Sago, areca nut, red pandanus fruits, coconut, vegetables, medicinal plants and others are identified, recorded and utilized by local people at all research locations. These NTFPs are utilized by local people for daily needs and earning extra incomes mainly when the self-demands are fulfilled. Crocodile leather is only recorded at Mamberamo Raya, as original habitat for river or estuarial crocodiles. Similarly, patchouli oil and candle oil are recorded only from FMUs Keerom and Sarmi, respectively. Beside sago, areca nut is a NTFP identified at all research locations, and utilized as additional materials in a community habit of *makan pinang*, and this might be also delivered from outside Papua when the demand is high.

Semi-processed and processed NTFPs

Local communities harvest NTFPs from inside forest in different forms, like fresh and consumed directly, whole plants or part of it, or being extracted and collected in raw materials for further processes. Semi-processed NTFPs are products resulted from first processing phase of raw material marketed locally or sold as further raw material for semi-processed to processed NTFPs. A flow chart showing an example of NTFP from harvesting (inside forest) to raw material, semi-processed to finished products (outside forest) of Sago (*Metroxylon sagu* Robt.) is described in Figure 3.

Sago is a well-known NTFP across Papua Province and utilized as staple food at coastal and swamp areas. At ripening stage (Figure 3.A) where starch content is the highest, sago is cut using axe and chain saw, the stem is then cleaned from all unwanted objects ranging from dried and rotten fronds, ferns, mud, soil, and the others. Sago pulps are collected by crushing sago pith (Figure 3.B), watering is applied during extraction by squeezing sago pulps to collect sago starch. Fresh and water free sago starch are collected and wrapped in sago leaves (Figure 3.C). At local market, 1.5 kg plastic bag of wet sago starch (Figure 3.D), here is classified as semi-processed product, are sold for local consumptions. One-kilogram standardized packaging of dried sago powder, classified for processed NTFPs, is created by local producer of dried sago starch or sago flour (Figure 3.E). Finally, sago flour could be made into several finished NTFPs or ended products with various flavours (Figures 3.F-3.H). If raw materials could be developed into further products or finished goods, they could offer numerous added values, not only for ecology and environment aspects but also for social economy and market chains.

Results of semi-processed and processed NTFPs identified and recorded from eleven research locations across Papua Province are tabulated Table 2. Table 2 indicates that seven semi-processed and three processed NTFPs are recorded from eleven research locations across Papua Province, and numbers of the semi-products vary among the research locations.

Table 1. NTFPs identified and harvested by local communities recorded from eleven research locations: seven FMUs and four FESBs across Papua Province, Indonesia

Name (Local, Indonesian, Latin)	Forest Management Units (FMUs)							Forest and Environment Service Branch (FESBs)			
	JC	S	SM	K	BN	Y	W	J	K	S	MR
<i>Sagu/Sago (Metroxylon sagu)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Buah pinang/Areca nut (Areca catechu)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Buah merah/Red fruits (Pandanus conoideus)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Kelapa/Coconut (Cocos nucifera)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Lebah madu/Honey (Apis spp.)</i>	•	-	-	-	-	•	•	•	•	-	-
<i>Rotan/Rattan Calamus spp.)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Bambu/Bamboo (Bambusa spp.)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Minyak lawang/Cullilawang oils (Cinnamomum culilawan)</i>	•	•	-	•	-	-	-	•	•	-	-
<i>Kulit masoi/Masohi/Masoi bark (Cryptocarya massoia)</i>	•	•	•	•	-	-	-	-	•	-	-
<i>Gaharu/Agarwood (Aquilaria spp.)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Damar/Resin (Agathis spp.)</i>	•	-	-	-	-	-	-	-	-	-	-
<i>Buah Aibon/Mangrove fruits (Bruguiera spp.)</i>	•	•	•	-	•	•	•	•	-	-	•
<i>Sarang semut/Ant nest (Myrmecodia platyrea)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Kulit kayu /Wood barks for painting</i>	•	•	-	•	-	-	-	•	-	•	-
<i>Gula aren/Palm sugar (Arenga pinnata)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Tumbuhan obat/Medicinal plants</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Sayur-sayuran/Vegetables</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Tanaman hias/Ornamental plants</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Daun tikar/daun pandan/Pandanus leaves (Pandanus spp.)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Tali kuning (Tinospora dissitiflora)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Buah nati/Nati fruit</i>	-	•	-	-	-	-	-	-	-	-	-
<i>Hutan mangrove/Mangrove</i>	•	•	•	-	•	•	•	•	-	•	•
<i>Ikan/Fishes</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Kepiting bakau/kepiting /mangrove crabs (Scylla serrata)</i>	•	•	•	-	•	•	•	•	-	-	•
<i>Udang bakau/udang windu/tiger shrimp (Penaeus monodon)</i>	•	•	•	-	•	•	•	•	-	•	•
<i>Buah kemiri/Kemiri/Walnut (Canarium spp.)</i>	•	•	•	•	-	•	•	•	•	•	•
<i>Gnemo/Melindo (Gnetum gnemon)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Sukun/Breadfruit (Artocarpus altilis)</i>	-	•	•	-	•	-	-	-	-	-	-
<i>Abon ikan/Fish floss</i>	•	•	•	•	•	-	-	•	•	-	-
<i>Daun gatal/Itchy leaves (Laportea aestuans)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Kulit kayu susu/Pulai bark (Alstonia scholaris)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Buah ketapang/Terminalia fruit (Terminalia catappa)</i>	-	-	•	-	-	-	-	-	-	-	-
<i>Daun keben/daun ketapang laut/Barringtonia leaves (Barringtonia asiatica)</i>	-	-	•	-	-	-	-	-	-	-	-
<i>Belimbing/Star fruits (Averrhoa carambola)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Daun dan buah sirih/ Piper leaves and fruits (Piper betle)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Arenga palm sugar</i>	•	-	•	-	-	-	-	-	-	-	-
<i>Coklat/Cokelat/Cacao (Theobroma cacao)</i>	-	•	•	•	•	-	-	-	-	-	•
<i>Durian (Durio zibethinus)</i>	•	-	•	-	-	-	-	-	-	-	-
<i>Rambutan (Nephelium lappaceum)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Minyak kayu putih/Eucalyptus oil (Melaleuca leucadendra)</i>	•	•	-	•	-	-	-	•	•	-	-
<i>Pewarna alami/Natural dying</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Jahe/Ginger (Zingiber officinale)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Kulit kayu/Wood bark Warmas</i>	-	-	-	•	-	-	-	-	-	-	-
<i>Tali kapor/Wood bark</i>	-	-	-	-	-	-	-	-	-	-	-
<i>Telaga biru/Blue cave lagoon</i>	-	-	-	•	-	-	-	-	-	-	-
<i>Kopi/Coffee (Coffea spp.)</i>	-	-	-	•	-	•	-	-	-	-	-
<i>Murbei/Murberry (Morus alba)</i>	-	-	-	-	-	•	-	-	-	-	-
<i>Pisang/Banana (Musa spp.)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Rumput laut/Seaweed (Eucheuma spp.)</i>	-	-	-	-	-	•	-	-	-	-	-
<i>Ikan tenggiri/Mackerel fish (Scomberomorus spp.)</i>	-	-	-	-	-	•	-	-	-	-	-
<i>Ampo/Nira aren</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Sayur Gedi-gedian/Gedi vegetables (Abelmoschus spp.)</i>	•	•	•	•	•	•	•	•	•	•	•
<i>Tepra/Selre/Anggur Papua (Sararanga sinuosa)</i>	-	•	-	-	-	-	-	-	-	-	-
<i>Minyak kenari/Candle oil (Canarium spp.)</i>	-	•	-	-	-	-	-	-	-	-	-
<i>Buah kenari/Candle nut (Canarium spp.)</i>	•	•	•	-	-	-	-	•	-	-	-
<i>Minyak nilam/Patchouli oil (Pogostemon cablin)</i>	-	-	-	•	-	-	-	-	-	-	-
<i>Serai/Lemon grass (Cymbopogon citratus)</i>	-	-	•	•	•	•	•	•	•	•	•
<i>Kulit buaya/Crocodile leather (Crocodylus spp.)</i>	-	-	-	-	-	-	-	-	-	-	•
<i>Ikan mujair/Tilapia fish (Tilapia sp.)</i>	-	-	-	-	-	-	-	-	-	-	•
<i>Nipah/Nypa (Nypa fruticans)</i>	•	•	•	-	•	•	•	•	•	•	•
<i>Nibung (Oncosperma tigillirium)</i>	•	•	•	•	•	•	•	•	•	•	•
Total	44	44	44	39	35	38	34	40	37	34	36

Notes: JC: Jayapura City, S: Sarmi, SM: Lintas Sarmi Mamberamo Foja, K: Keerom, BN: Biak Numfor, Y: Yapen, W: Waropen, J: Jayapura, MR: Mamberamo Raya, •: Present, -: Absent

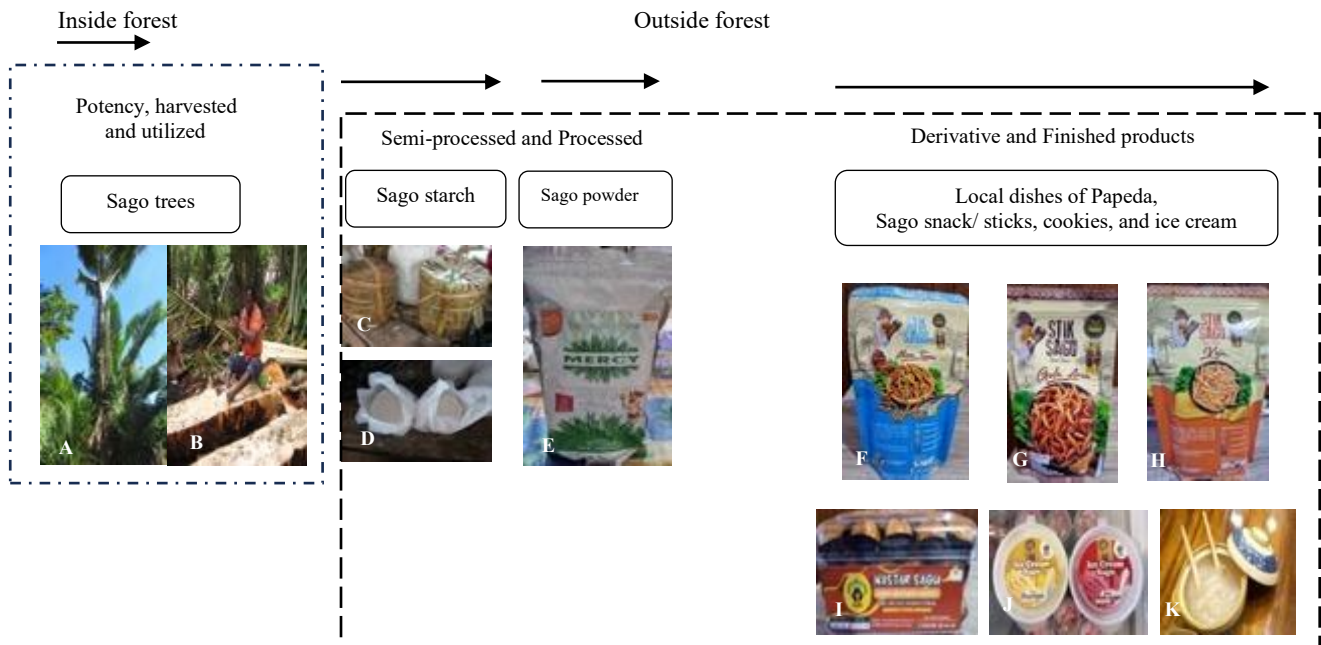


Figure 3. Flow chart of the utilization of Sago from raw material, semi-processed, processed to finished NTFPs in Papua Province, Indonesia. A. Sago tree, B. Bucking sago tree into 1m long, C. Sago starch wrapped in sago leaves, D. Sago starch stored in plastic bags sold at local market, E. Sago powder, F. Sago stick with tuna flavor, G. Sago stick with areca sugar flavor, H. Sago stick with cheese flavor, I. Sago peanut cookies, J. Ice cream sago, K. Local dishes of Papeda

Table 2. Summary of semi-processed and processed NTFPs identified and recorded across Papua Province, Indonesia

Name	Forest management units							Forest and environment service branch			
	JC	S	SM	K	BN	Y	W	J	K	S	MR
Semi-processed NTFPs											
Wet sago starch packed in plastic bag	●	●	●	●	●	●	●	●	●	●	●
Red fruit extract oil	●	●	●	●	●	●	●	●	●	●	●
Slized and dried Ant nest	●	-	●	-	-	-	-	●	-	-	-
Ambaidiru roasted coffee	-	-	-	-	-	●	-	-	-	-	-
Stengkol roasted coffe	-	-	-	●	-	-	-	-	●	-	-
Wood bark painting	●	-	-	●	●	-	●	●	●	-	-
Mangrove ecotourism	●	●	-	-	●	●	●	●	-	●	●
Total	5	2	1	3	3	2	2	5	4	2	3
Processed NTFPs											
Honey	●	●	-	●	-	●	●	-	●	-	●
Sago Flour	●	-	-	-	-	-	-	-	●	-	-
Agarwood leaf tea bag	-	●	-	-	-	-	●	-	●	-	-
Total	3	2	0	1	0	1	2	0	3	0	1

Notes: JC: Jayapura City, S: Sarmi, SM: Lintas Sarmi Mamberamo Foja, K: Keerom, BN: Biak Numfor, Y: Yapen, W: Waropen, J: Jayapura, MR: Mamberamo Raya, ●: Present, -: Absent

Wet sago starch in plastic bags and red fruits extract are the most semi-processed products recorded at all research locations. For local consumption, the wet sago starch is used for many purposes, such as making famous local dishes originally from Papua (i.e. papeda), sago cookies, and bagea (i.e. baked sago starch mixed with grated coconut and sugar wrapped in sago leaves), and other processed sago starch. Semi-processed red fruit extract is made from red fruit pandanus (*Pandanus conoideus*) by boiling the red fruit on pans to separate oil and its paste.

Red fruit extract oil is packed on recycle bottles or plastic bottles and sold at local market. This red fruit extract oil is in dark and dirty color without any attributes of label, brands, and nutrition facts. Therefore, further advanced processes are required to develop finished products. Three processed NTFPs from Papua Province, namely honey, sago powder, and agarwood leaf tea bag are traded at local markets with local made packaging. Honey is packed using recycle bottles without label and attributes, similar to agarwood leaf tea bag packaged with sealed plastic without

label and product attributes, but sago dried flour is packed using Indonesian National Standard/SNI (Figure 3.E).

Finished NTFPs

Finished NTFPs are NTFPs traded and displayed at a forestry gallery located in Abebura, Jayapura City officially under the supervision of Forestry and Environment Office

of Papua Province. This shop sells NTFPs from the eleven-research locations across Papua Province. This forestry shop or gallery does both online and offline shopping. Summary of finished NTFPs identified and recorded from the forestry gallery in Jayapura City is presented in Table 3.

Table 3. Summary of finished NTFPs identified and recorded from forestry gallery in Jayapura City, Papua Province, Indonesia

Name	Forest management units							Forest and environment service branch			
	JC	S	SM	K	BN	Y	W	J	K	S	MR
Sago pastries	●	-	-	●	-	-	-	-	-	-	-
Sago ice creams	●	-	-	-	-	-	-	-	-	-	-
Areca nut coffee	●	-	-	-	-	-	-	-	-	-	-
Red fruit capsules	●	-	-	-	-	-	-	-	-	-	-
Red fruit oil	●	-	-	-	-	-	-	-	-	-	-
Virgin Coconut Oil (VCO)	●	-	-	-	-	-	-	●	-	-	-
Charcoal briquettes	●	-	-	-	-	-	-	-	-	-	-
Orchid flower	●	-	-	-	-	-	-	-	-	-	-
Eco print products (T-shirt, goody bags)	●	-	-	-	-	-	-	-	-	-	-
Coco fibers media	●	-	-	-	-	-	-	-	-	-	-
Agarwood leaf tea bag	-	●	-	●	-	-	-	-	●	-	-
Cacao powder	-	-	●	-	●	-	-	-	-	-	-
Eucalyptus oil	-	-	-	-	●	-	-	-	-	-	-
Assorted cakes from mangrove fruits	-	-	-	-	●	-	-	-	-	-	-
Bokashi fertilizer compost	-	-	-	-	●	-	-	-	-	-	-
Red ginger juice	-	-	-	-	●	-	-	-	-	-	-
Various wooden gifts (boats, keychains)	-	-	-	-	●	-	●	-	-	-	-
Eco-print (bags, shawls, cup);	-	-	-	-	●	-	●	-	-	-	-
Mangrove leaf tea;	-	-	-	-	●	-	●	-	-	-	-
Agarwood oil	-	-	-	-	-	-	●	-	-	-	-
Gifts (e.g., key holders from plants)	-	-	-	-	-	-	●	-	-	-	-
Mulberry tea bag	-	-	-	-	-	●	-	-	-	-	-
Seaweed stick	-	-	-	-	-	●	-	-	-	-	-
Ruiweed (Yapen's seaweed stick brand)	-	-	-	-	-	●	-	-	-	-	-
Banana chips	-	-	-	-	-	●	-	-	-	-	-
Mackarel crackers	-	-	-	-	-	●	-	-	-	-	-
Ambaidiru ground coffee	-	-	-	-	-	●	-	-	-	-	-
Senggi sago flour	-	-	-	-	-	-	-	●	-	-	-
Sago biscuits	●	-	-	-	-	-	-	●	-	-	-
Sengkol ground coffee	-	-	-	-	-	-	-	-	●	-	-
Wooden gifts/ashtray and others	-	-	-	-	-	-	-	-	●	-	-
Sago cookies and cake	-	-	-	-	-	-	-	●	-	-	-
Crocodiles leather products	-	-	-	-	-	-	-	●	-	-	-
Cassowary hat ornaments	-	-	-	-	-	-	-	●	-	-	-
Vanilla	-	-	-	-	-	-	-	●	-	-	-
VCO capsules	-	-	-	-	-	-	-	●	-	-	-
VCO soaps	-	-	-	-	-	-	-	●	-	-	-
Sago sticks (three flavours)	●	-	-	●	-	-	-	●	-	-	-
Sago ice cream	●	-	-	-	-	-	-	●	-	-	-
Mercy sago flour	-	-	-	-	-	-	-	●	-	-	-
Tree bark woven clothes	-	●	●	-	-	-	-	●	-	●	-
Koteka with various sizes and patterns	●	-	-	-	-	-	-	●	-	-	-
Wooden basket parcel	-	-	-	-	-	-	-	-	-	●	-
Woven purses	-	-	-	-	-	-	-	-	-	●	-
Coconut fibers planting media	-	-	-	-	-	-	-	-	-	-	-
Cenderawasih sago flour	-	-	-	-	-	-	-	●	-	-	-
Sukun crackers	-	-	-	-	-	-	-	●	-	-	-
Various wooden gifts	-	-	-	-	-	-	-	●	-	-	-
Total	14	2	2	3	8	6	5	17	3	3	0

Note: JC: Jayapura City, S: Sarmi, SM: Lintas Sarmi Mamberamo Foja, K: Keerom, BN: Biak Numfor, Y: Yapen, W: Waropen, J: Jayapura, MR: Mamberamo Raya, ●: Present, -: Absent

There are 48 finished NTFPs traded at the forestry gallery in Abepura, Jayapura City. The highest number of finished NTFPs is recorded from FESB Jayapura (17), followed by FMU Jayapura City (14), and FESB Mamberamo Raya is the lowest with no finished NTFP. The number of finished NTFPs could be increased when single product has different variant in color, shapes, usages, or ornaments as in the case of wooden gifts. There are various wooden gifts produced from each research location, such as wooden astray, key holders, miniatures for traditional boats and huts, smoking pipes, and others. Also, *Noken* have numerous shapes, sizes, and raw material made from pandanus leaves, fibers (wood bark cambium, pineapple leaves, orchid stem and others). Table 3 also highlights that sago could be processed into numerous finished products, including those ready to be consumed such as sago sticks with several flavours, ice cream sago, sago cookies and so on.

Eight finished NTFPs for green economy development

Eight finished NTFPs from the forestry gallery at Abepura Jayapura City Papua Province are selected, namely sago’s products (SG), cacao powder (CP), coffee powder (CF), honey (HN), eucalyptus oil (EO), ant nest tea (AT), agarwood tea (AG), and eco print products (EP). With respect to the green economy development in Papua province, the eight finished NTFPs are mapped alongside to green economy variables and itemized results are presented in Table 4.

Table 4 shows that eco print (EP) has the highest value (94%) that meet green economy variables, followed by sago (SG) with 90%, coffee powder (CF) and ant nest tea (AT) with 87% each, while cacao powder (CP) has the lowest (68%). Sago and eco print meet green economy variables for economic potential with three sub-variables, such as raw material originality, gained skill of local communities, and market, respectively, and supported by nine indicators from endemic, planted, typical Papua to international markets. These two NTFPs, sago and eco print, also accomplish other three green economy variables of ecological benefit, added values and challenges as well as their criteria and indicators.

Feasibility analysis of the eight selected NTFPs using Benefit- Cost Ratio (B/C ratio) and Break Event Point (BEP)

Feasibility analysis was conducted to assess economic feasibility in nominating the eight finished NTFPs based on their B/C ratio values, dan BEP for green economy development in Papua Province. Mean costs for variables, fixed, total revenues, B/C ratio values, and BEP values for the eight finished NTFPs were calculated with the results are presented in Table 5.

Table 5 indicates that eco print products resulted the highest B/C ratio value (3.94) followed by Ant nest tea with (2.56) and coffee powder (1.53), and they are classified into high level of priority. Sago with B/C ratio value of 1.18 belongs to medium priority and the rest NTFPs are categorized in into low level of priority because their B/C ratio is < 1.0. With regard to BEP, ant nest tea

has the lowest fixed cost value for IDR 2.5 million followed by eco print products for IDR 22 million. The production of ant nest tea does not require huge investment in machineries, tools or others as indicated with the lowest fixed cost (IDR 1.4 million) for buying labeled packaging and wrapped boxes. This is in contrast to eco print products, where majority of their raw material, such as T-shirt and other pressed machines, as indicated by their higher fixed and variables costs, IDR 17.1 million and IDR 11.4 million, respectively.

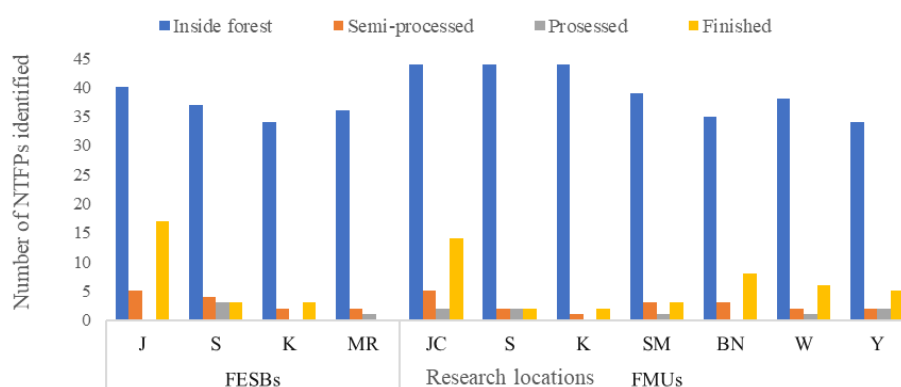
Table 4. Eight finished NTFPs for green economy development in Papua Province, Indonesia, selected using several variables, criteria and indicators

Green economy variables	Eight finished NTFPs							
	SG	CP	CF	HN	EO	AT	AG	EP
Economic potential								
<i>Raw material originality</i>								
Endemic	●	-	-	-	-	●	●	●
Planted	●	●	●	-	●	-	-	●
Typical Papua	●	-	●	●	-	●	●	●
<i>Gained skill of local communities</i>								
Training	●	-	●	●	●	●	●	●
Workshop	●	-	●	●	●	●	●	●
Government program	●	●	-	-	●	●	-	●
<i>Local technology content</i>								
Drying	●	●	●	●	●	●	●	●
Roasting	-	-	●	●	-	-	-	-
Packaging	●	●	●	●	●	●	●	●
Grinding	-	●	●	●	-	●	●	-
Pounding	-	-	-	-	-	-	-	●
<i>Markets</i>								
Local	●	-	●	-	●	●	-	●
Regional	●	●	●	●	●	●	●	●
National	●	●	●	●	●	●	●	●
International	●	-	●	●	●	●	-	●
Ecological benefit								
<i>Community direct involvement</i>								
Planting	●	●	●	-	●	-	-	●
Harvesting	●	●	●	●	●	●	●	●
Drying	●	●	●	●	●	●	●	●
Processing	●	●	●	●	●	●	●	●
<i>Offering incomes, jobs, opportunity for small business creativities</i>								
Informal works	●	●	●	●	●	●	●	●
Extra incomes	●	●	●	●	●	●	●	●
Home industry	●	-	●	●	-	●	●	●
<i>Environmental values</i>								
No pollution	●	●	●	●	●	●	●	●
Low emission	●	●	●	●	●	●	●	●
Labor intensive	●	●	●	-	●	●	-	●
Simple technology	●	●	●	●	●	●	●	●
Added values								
<i>Branding and labelling</i>								
Legal permits	●	●	●	●	●	●	●	●
Packaging	●	●	●	●	●	●	●	●
Challenges								
<i>No-competitor</i>								
Sustain market supply	●	●	●	●	●	●	●	●
Total indicators (31)	28	21	27	24	25	27	23	29
Percentage to total (%)	90	68	87	77	81	87	74	94

Note: SG: Sago, CP: Cacao powder, CF: Coffee powder, H: Honey, EO: Eucalyptus oil, AT: Ant nest tea, AG: Agarwood leaf tea, EC: Eco print

Table 5. Summary of economic feasibility analysis for eight finished NTFPs using B/C Ratio and BEP

Eight finished NTFPs	Mean Cost (IDR. x million)			Unit price (IDR)	Feasibility score		Level of Priority
	Variable	Fixed	Revenue		BEP (IDR x million)	B/C Ratio	
Sago flour, Sago sticks, Sago snacks	21.1	21.3	26.9	40,000 25,000	98.7	1.18	Medium
Cacao powder	12.32	36.6	13.5	50,000	178.6	0.88	Low
Coffee powder	13.3	36.6	25	130,000	78.2	1.53	High
Honey	12.6	46.2	13.1	170,000	271.3	0.80	Low
Eucalyptus oil @ 250 ml	12.6	46.2	13.4	160,000	257.7	0.81	Low
Ant nest tea @ 1kg	4.9	1.4	12.5	150,000	2.3	2.56	High
Agarwood tea bag	6.1	56.7	3.3	50,000	109.7	0.55	Low
Eco print products	11.4	17.1	45.0	350,000	22.0	3.94	High

**Figure 4.** Gap of NTFPs utilization between inside and outside forest across Papua Province, Indonesia

Discussion

Inside forest, NTFPs are available as important parts of forest ecosystems, balancing micro climates and enriching forest ecology. In contrast to timber or trees, the NTFPs cover all biological products both for flora and fauna extracted from the forest with limited impacts to forest ecosystem (Murdjoko et al. 2021) including fruits, flower, tuber, leaves, liana, epiphytes, orchids, mushroom, vegetable, animal, and so on (Ap et al. 2023; Wahyudi et al. 2023). They could be directly consumed fresh, burned or smoked on firewood, and processed for self-consumption or trade (Latifah et al. 2023). NTFPs are utilized for various purposes from staple foods, vegetables, sources of vitamins and mineral, sources for animal and vegetable fats, energy or firewood, medicinal purposes, and others (Awirya et al. 2025).

There are substantial gaps between NTFPs inside and outside forest across the locations in Papua Province meaning that NTFPs are primarily harvested and utilized by local communities for each research location as illustrated in Figure 4. These facts underline that it is essentially encouraging to alter NTFPs from fresh and raw materials to semi-processed and finished NTFPs to optimize profitability, multiple impacts, fulfill green economy principles, and local resources utilization and participation (Ap et al. 2025).

Figure 4 illustrates that FMU Jayapura City, Sarmi and Keerom have higher number of NTFPs inside forest, where each FMU has 44 NTFPs but their finished NTFPs are different one another, where FMU Jayapura City has the

highest finished NTFPs (11) and Sarmi and Keerom each has 2 finished NTFPs. Similarly, FESB Jayapura also produces the highest finished NTFP (17) compared to other FESBs. The gap between NTFPs inside and outside forest indicate that majority NTFPs are harvested by local community in order to meet their daily consumption instead for cash incomes (Wahyudi et al. 2024), which requires selling the raw material, fresh and semi-processed NTFPs at local or traditional markets (Rahawarin 2017).

Sago (*M. sago*) is a typical tropical palm producing carbohydrate and utilized as source of staple foods for local communities living in the eastern part of Indonesia, such as Moluccas, Celebes and West Papua and Pacific Island nations. In Jayapura, a capital city of Papua Province, throughout down streaming program, sago starch could be processed into various homemade sago based-products, likes sago biscuits, sago cake, brownish, pearl sago, and others, which are massively available at local markets during Christmas, New year holiday, and Eid Mubarak times. Sago derived products are produced by small and household industries or small-local business entrepreneur owned by local communities including Papuans using local materials, simple eco-friendly technology, and labor intensive predominantly women. Sago end products in Papua Province are different to those reported from Meranti District in Riau Province, where sago starch are processed into a wide range of products including sago noodle, sago fat, kapuru, sago mutiara, and others (Syartiwidya et al. 2019; Simangunsong et al. 2020). Red fruit and coconut also could be developed for green

economy by producing their derivative or finished products. Down streaming activities with local raw material based, eco-friendly technology and labor intensive will contribute to innumerable impacts for environmental, ecology, social and economy of local people values, that fulfill green economy obligations (Nandy et al. 2022; Zhironkin and Cehlár 2022).

The eight finished NTFPs for green economy development in Papua Province have been selected and identified comprising of sago products (S), cacao powder (CP), coffee powder (CF), honey (HN), eucalyptus oil (EO), ant nest tea (AT), agarwood leaf tea (AG), and eco prints (EP) evaluated using variables, sub-variables and indicators. Eco print and sago have the highest percentage, 29 of 31 indicators or 94% and 28 of 31 indicators or 90 %, respectively, with an average of 82% for all finished NTFPs. Cacao is introduced crops planted massively in 1990s in Papua Province, and today this crop is no longer productive and changed into other crops. Sago is the only NTFP without confront to other commodities due to substantial role in West Papua, sustained market supply and natural abundance across Papua Province.

These finished NTFPs have advanced characteristics for raw material originality, attracting demands from local, national and international customers. They also offer several ecological benefits such as community direct involvement in planting and processing, alternative household incomes, informal works, extra job, and household small industry opportunities. These finished NTFPs are excellent examples how homegrown raw material with local wisdom, technology and community commitments are combined to produce esteemed products designed for green economy development. Additional attributes of branding, labelling and certification will expand added values of the finished NTFPs proper for green economy commodities.

The eight finished NTFPs have B/C ratio value range from 0.80 to 3.94, classified into three clusters of priority: low priority (< 1.0), medium (1.0-1.5), and high priority (> 1.5). Eco print products, ant nest tea, and coffee powder are clustered into high priority, meaning that these three products could be nominated as the primary commodity for green economy development in Papua Province. Similarly, sago ended-products (flour, snacks, and sticks) with B/C ratio of 1.18 had medium level of priority, could be recommended for future green economy development. The NTFPs with low level of priority could be developed as green economy commodities but attention has to be focused on improved sales, promoting using social media, e-marketing promotions, and location tagging on online maps which will intensify the public attentiveness and acceptance worldwide. Native commodities combined with local wisdoms, technology and culture will enhance customers' appreciations in admitting eco-friendly products, nature-oriented value, and green living attitudes (Aldieri and Vinci 2018; Wayan 2020; Nandy et al. 2022). Agarwood is the product that requires further development because of their packaging and supporting materials are supplied from outside Papua, and competition with similar products in online trading. This will result in an increase in

costs and promotions that are not yet achieving their full potential. NTFPs with high category of BEP are honey and eucalyptus oil products as it is influenced by fixed costs associated with the expensive primary and secondary machinery required for oil and honey refining, necessitating optimal sales to attain the BEP.

In conclusion, this study finds that at least 61 NTFPs inside forest were identified and recorded from eleven research locations across Papua Province, seven semi-processed and three processed and 48 finished products classified for NTFPs outside forest. Sago end products (flour, sticks and snacks), cacao powder, coffee powder, honey, eucalyptus oil, ant nest tea, agarwood tea bag, and eco print are the eight finished NTFPs selected for green economy development in Papua Province. These eight finished NTFPs meet the green economy indicators with an average of 82% with eco print has the highest value (94%) followed by sago (90%). Finished NTFPs with high level priority are eco print, ant nest tea and coffee powder with B/C ratio of 3.94, 2.56, and 1.53, respectively. Medium level priority belongs to sago products with B/C ratio of 1.18, and the rest of the eight NTFPs have low level priority with B/C ratio < 1.0. Therefore, the four finished NTFPs for highly and medium priority could be nominated as green economy commodities of forest products in Papua Province. With regard to the local raw material uniqueness and identity, sago products could be primarily recommended as this NTFP could be processed into various end products using local technology, indigenous skills, small business, and women involvements.

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