

Environmentally-Based Rural Economic Development Through Multi-Product Downstreaming of Arenga Pinnata

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Abstract

Arenga pinnata is one of the plant commodities that has superior benefits in Indonesia. Besides being able to be processed as a source of food (in the form of fruit and drinks made from sap), the product of this plant can function as a material for making bricks, as a constituent of vehicle body fibers and concrete fibers. In addition, this plant provides an environmental impact that can withstand landslides and maintain groundwater circulation. However, the utilization of various plant products is still constrained and not optimal. The exploitation of a product that causes environmental damage is a significant issue that must be solved immediately. The purpose of this study is to analyze and produce a model that fits in explaining environmental-based economic development through the multi-product and multi-function of Arenga Pinnata. The sample of this study was 94 Arenga Pinnata farmers with an average land area of 1.52 hectares in West Sumatra, Indonesia. Data were collected using the Arenga Pinnata Multi-Product and Multi-Function (AP-MPMF) instrument. Data analysis using Structural Equation Model (SEM) and analysis of loading factor between model variables. The results showed that the welfare of farmers could be increased by optimizing the environmental function of Arenga Pinnata so that it can contribute to economic improvement.

Keywords: Economic Development, Environmental, Downstreaming, Arenga Pinnata

Introduction

The prospect of developing the Arenga pinnata plant is one of the cornerstones and the national agricultural agenda in Indonesia. Arenga Pinnata's ability to produce various processed products is an opportunity to create an economic flow that relies on this plant (Victor & Orsat, 2018; Yusof & El Pebrian, 2016). The use-value of Arenga Pinnata can be obtained in all parts of the plant. Research proves that Arenga Pinnata fibers are used as reinforcement for vehicle body covers (Sherwani, Zainudin, Sapuan, Leman, & Abdan, 2021; Suriani, Ruzaidi, & Nair, 2020), and fibers are used as a concrete mixture as a pressure-retaining element (Alhijazi, Zeeshan, Safaei, Asmael, & Qin, 2020; Suriani et al., 2021). Arenga pinnata fruit is one of the traditional food commodities and medicines (I. Azhar, Risnasari, Muhdi, Srena, & Riswan, 2019; Ilyas et al., 2019; Sherwani et al., 2021). Nira Arenga Pinnata is an ingredient for making ethanol, brown sugar, and palm wine (Ansar,

Nazaruddin, & Azis, 2021; Ansar, Nazaruddin, Azis, & Fudholi, 2021; Erliana, Widjaja, Altway, & Pudjiastuti, 2020; Sangian, Tamuntuan, Mosey, Suoth, & Manialup, 2017). The root extract of *Arenga Pinnata* can be used as an ingredient for making diuretic drugs (Hermansyah, Novia, Sugiyama, & Harashima, 2015; Sari, Anwar, Dwipa, & Hervani, 2021). In addition, *Arenga Pinnata* can control groundwater circulation and resist the rupture of unstable soil structures, so it can be used as a plant that can control floods, droughts, and landslides (Soeprbowati, Jumari, Saraswati, Suhry, & Gell, 2021; Yudhiantami, Reynanda, Pertiwi, & Wicaksono, 2021).

However, even though it has been supported by the national policy of *Arenga Pinnata* plantations, the utilization of this plant is still not optimal. There are still not many unique lands for *Arenga Pinnata* plantations that can produce products from this plant to the maximum, such as similar plants. Similar conditions were also found at the research site in West Sumatra, Indonesia. More than 90% of *Arenga Pinnata* farmers used their land to plant *Arenga Pinnata* for less than 1 hectare. This condition certainly does not produce products that are of great use to farmers and increase the sectoral economy (I. Azhar et al., 2020; Martini et al., 2012; Widayati, Rianse, Hanafi, & Abdullah, 2018). Other findings in the same area also show that *Arenga pinnata* plants are not grown under management based on agricultural science but are only allowed to grow on their own.

One of the strategic efforts that can accelerate the utilization of *Arenga Pinnata* is by conducting studies and implementing products downstream (Haryoso, Zuhud, Hikmat, Sunkar, & Darusman, 2020). This program can be an opportunity to optimize the function of *Arenga Pinnata* economically and environmentally (Chalid, Yuanita, & Pratama, 2015; Gunawan, Ramadhan, Iskandar, & Partasmita, 2017; Riley & Fuentes, 2011; Sanyang, Sapuan, Jawaid, Ishak, & Sahari, 2016). Product downstream will increase welfare by absorbing many workers based on the many products produced by *Arenga Pinnata* (Z. Azhar, Aimon, Elida, & Ardi, 2018; Lischeid, 2014; Warziniack, 2014). In addition, environmental maintenance and its impact can be carried out as a follow-up study of the downstream area of *Arenga Pinnata*. This impact is followed by efforts to develop supportive and mainstay industries selectively through the preparation of skilled and competent human resources in the industrial sector and increasing mastery of technology.

In essence, the existence of downstream product *Arenga Pinnata* must be in line with an in-depth study related to the trade-off between economic growth and the environment (Environmental Kuznets Curve) (Bilgili, Nathaniel, Kuşkaya, & Kassouri, 2021; Khan et al., 2021; Wei et al., 2021). Environmental damage due to the optimization of the economic element of a product is a variable that is of particular concern. In addition, in the long term, environmental damage as a result of the exploitation of the economic elements of a biological product will impact the welfare and happiness of the community (Martini et al., 2012; Widayati et al., 2018). So that the interrelationships of these elements tend to fluctuate and need an in-depth study so as not to damage each other (I. Azhar et al., 2021; Ilyas et al., 2021; Sanyang et al., 2016; Withaningsih, Parikesit, Iskandar, & Putri, 2019). In other words, if environmental conditions, economic growth, and community welfare studies are not the focus of product downstream, it will threaten the long-term sustainability of economic growth (I. Azhar et al., 2019; Haryoso et al., 2020; Riley & Fuentes, 2011; Rinawati, Reflinur, Dinarti, & Sudarsono, 2021; Widayati et al., 2018; Yudhiantami et al., 2021).

One of the efforts to optimize the downstream of *Arenga Pinnata* plant products is to use studies on optimizing plant products and functions. To reduce the environmental damage, it is necessary to study the products produced by *Arenga Pinnata* by applying the zero-waste

principle (Erliana et al., 2020; Fitriana, Suwanto, Jatmiko, Mursiti, & Prasetyo, 2020). It is hoped that each product produced will not become a pile of garbage that causes environmental damage. In addition, the study of the multi-function of the Arenga Pinnata plant is also a supporting variable for downstream studies (Z. Azhar et al., 2018; Warziniack, 2014). One example is the function of Arenga Pinnata plants in resisting cliff soil cracks and the ability to maintain the circulation of groundwater supplies. Then the process of planting and utilization of Arenga Pinnata will be optimal along with the existence of the plant product itself (I. Azhar et al., 2021; Haryoso et al., 2020; Sangian et al., 2017).

In realizing the use of Arenga Pinnata plants economically and environmentally through the downstream process, it is necessary to have a model that describes the relationship between variables sustainably and sustainably. This model is the basis for the execution of Arenga Pinnata downstream. The model of the Arenga Pinnata downstream is expected to be a turning point that can grow the economy of the community (rural areas) while at the same time being able to reduce environmental degradation. Therefore, there is a need for a study that looks at the relationship between the economic use of Arenga Pinnata multi-products concerning community economic growth and the resulting environmental impact.

In line with the importance of this study, the focus of this research is to analyze the model of improving community welfare that is environmentally sound through optimizing the multi-product and multi-function Arenga Pinnata plant. This model will be the flow and execution guide for the downstream process of Arenga Pinnata optimally while maintaining the resulting environmental impact.

Materials and Methods

Study Location

Research on environmental-based rural economic development models through the multi-product Arenga Pinnata was conducted in the Andaleh Baruh Bukik area, Sungayang, Tanah Datar District, West Sumatra Province. The area that spreads the cultivation of Arenga Pinnata is 3,820 hectares with coordinates -0.3846152706245745, 100.64529511196827. The total population of 4,832 generally has land for farming, although not all of them plant their land with Arenga Pinnata. The farmers who were recorded as focusing on cultivation were 135 families with an average planting area of 1.49 hectares and an average of 105 stems of Arenga Pinnata for each farmer. For the planting height of Arenga Pinnata, this area includes highlands (at an altitude of 600 – 1200 meters) with an average rainfall of 1200 mm per year.

Participant

This study involved 94 Arenga Pinnata farmers with diverse demographic dynamics, according to Table 1. Of the 135 farmers known to have Arenga Pinnata commodities, only 94 farmers were willing to be the data source and fulfilled the informed consent to use the data in this study.

On average, Arenga Pinnata Farmers are over 40 years old (73.41%). Data exposure shows that less than 26.59% of Arenga Pinnata farmers are categorized as young and under

40 years old. Arenga Pinnata farmers are also farmers with low education. In general, farmers only graduated from elementary school (45.74%), and none graduated from college.

Table 1. Demographic data of Arenga Pinnata farmers and agricultural areas

		f	%
Age of farmer	20 - 30 years old	7	7,44
	31 - 40 years old	18	19,15
	41 - 50 years old	31	32,98
	51 -60 years old	26	27,66
	above 70 years old	12	12,77
Level of education	Elementary school	43	45,74
	Junior high school	34	36,17
	Senior high school	17	18,09
	Diploma	0	0,00
	Bachelor degree	0	0,00
Land area	0,01 - 2,88 ha	80	85,11
	2,89 - 5,76 ha	10	10,64
	5,77 - 8,54 ha	1	1,06
	8,05 - 11,32 ha	1	1,06
	11,33 - 14,1 ha	2	2,13
Number of rods	1 – 061	21	22,34
	62 - 102	39	41,49
	103 – 143	12	12,77
	144 - 184	11	11,70
	185 - 225	11	11,70

For planting areas, farmers generally only have 0.01 to 2.88 hectares of planting land. This happens because the land used is not entirely intended for planting Arenga Pinnata. The number of Arenga Pinnata plants also confirmed this finding, that only 41.49% of farmers planted more than 62 stems on their land.

Measurement

Research data retrieval was carried out using an Arenga Pinnata Multi-Product and Multi-Function (AP-MPMF) instrument. The development of this measuring instrument first went through an expert judgment testing process to get the suitability between the constructs measured and the measuring items (Clark & Watson, 2019). There were nine experts involved with development economics and environmental science expertise. Measurement of validity with expert judgment got Aiken's V coefficient value of 0.97 with the interpretation of all experts stating that the item was suitable for measuring variable constructs. Furthermore, validity testing was carried out using Confirmatory Factor Analysis (CFA) to measure the suitability and strength of the items in constructing the measured variable constructs (Lin, Broström, Nilsen, Griffiths, & Pakpour, 2017). The CFA test resulted from 25 items; 24 items were fit to be used in the study. Furthermore, the measurement of the reliability of the instrument using Cronbach's Alpha analysis was carried out. The test resulted in a Cronbach Alpha value of 0.91, so it can be interpreted that the instrument has a stable ability to measure research variables.

Data Collection Process

Respondents taken in this study were sugar palm farmers as sugar palm plantation managers who interacted directly with plantation products. In the preparation of data collection, collaboration with the government related to the research target area was carried out. Permission to collect data is one way to maintain the credibility of the results and the code of ethics in research. Data collection was carried out for one month. The time-consuming process caused by Arenga Pinnata farmers must be met one by one to obtain accurate data. In addition, complete data collection was also carried out by in-depth interviews as a form of refinement of secondary data from the study.

Data Analysis

Re-identifying field findings preceded data analysis by considering the completeness of the data and the possibility of data corruption due to administrative incompleteness. After the completeness of the data is confirmed, the data is then analyzed by first testing the requirements of the model development. Chi-square analysis was performed to analyze the developed fit model. Considering that the sample is below 100, then the fit model testing also involves other analysis; Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Bollen's Incremental Fit Index (IFI), Relative Noncentrality Index (RNI), Root mean square error of approximation (RMSEA), Goodness of fit index (GFI).

A Structural Equation Model (SEM) was carried out to conduct testing and analysis of the developed model. Considering the accuracy of the relationship between latent variables with optimal considerations and rational use of this method. In addition, an analysis of the loading factor value was also carried out to see the strength of the relationship between variables in compiling the model. SEM processing was carried out using Jeffreys' Amazing Statistics Program (JASP) software version 0.9.2.

Results and Discussion

Testing the multi-product-based economic development model of the Arenga Pinnata plant begins with testing the fit model through Chi-square analysis. Following the results in Table 2, it can be seen that the AIC and BIC values of the developed model are pretty good, with no difference between the ideal model and the model developed in the study.

Table 2. Chi-square Analysis of Environmental-Based Economic Development Model for Arenga Pinnata Plants

	AIC	BIC	n	Baseline test			Difference test		
				χ^2	df	p	$\Delta\chi^2$	Δdf	p
Model	4110.172	4308.549	94	652.054	446	< .001	652.054	446	< .001

To ensure the measurement of the suitability of the model, an additional fit measure is carried out through several indices. In the overall measurement of the model suitability index, it can be seen in Table 3 that the overall measurement shows the model is declared fit. The RMSEA index shows a value of 0.133, indicating that the level of model measurement inaccuracy is low. On the other hand, an excellent condition is seen in the GFI index of 0.972. In other words, the model is classified as fit and following the ideal model.

Table 3. Additional fit measure model

Index	Value
Comparative Fit Index (CFI)	0.725
Tucker-Lewis Index (TLI)	0.692
Bollen's Incremental Fit Index (IFI)	0.731
Relative Noncentrality Index (RNI)	0.725
Root mean square error of approximation (RMSEA)	0.133
Goodness of fit index (GFI)	0.972

Furthermore, an analysis of the model using SEM was carried out, with the results presented in Figure 1.

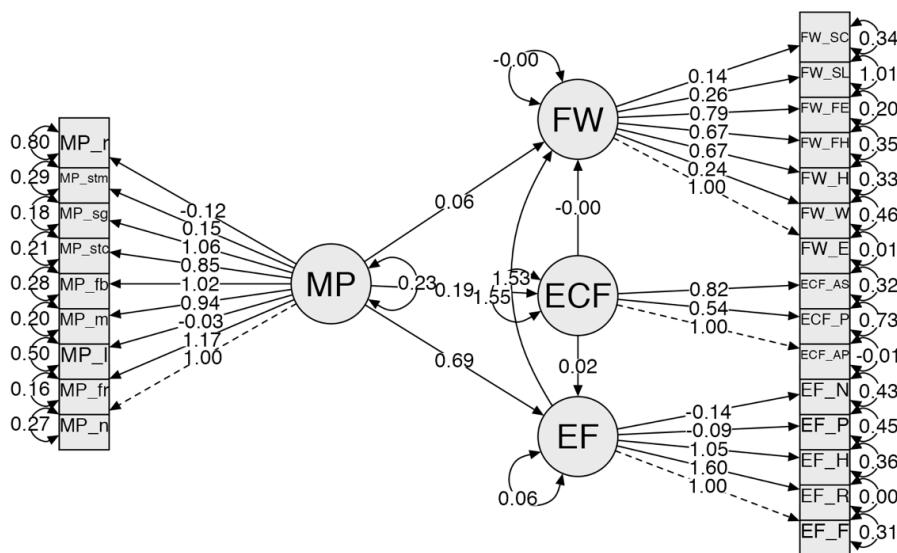


Figure 1. Structural Model of Economic Development based on Arenga Pinnata Multi-Product

Based on the model in Figure 1, it can be seen that the multi-product Arenga Pinnata (MP) does not directly impact the welfare of farmers. However, the impact of the product has a significant relationship on the economic function (EF). This condition is seen in the coefficient of the estimated loading factor between MP and EF of 0.69 with a p-value <0.001. An increase in EF will impact farmers' welfare (FW) with a loading factor coefficient of 1.53 with a p-value <0.001.

The product from Arenga Pinnata that has a significant impact on the model is the Arenga Pinnata fruit (MP_fruit) with a loading factor value of 1.17, with a p-value of <0.001 as described in Table 4. The research sample uses Arenga Pinnata fruit for processing purposes raw food and making sugar palm fruit jelly. The use of Arenga Pinnata rind as a material for making brackets is also one factor contributing to the environmental function of the sugar palm, which indirectly affects the welfare of farmers. The following product with an environmental impact and the model developed is Sago and Fiber from Arenga Pinnata (MP_sago and MP_fiber), with loading factor values of 1.06 and 1.02 (in Table 4). Sago obtained from Arenga Pinnata is used as the primary material for making flour and the basic material for paper pulp. Meanwhile, palm fiber is still the primary commodity in producing household appliances (brooms, mats, water filters, and ropes) and a mixed material in environmentally friendly concrete. In addition, fronds, sticks, and neera are also the leading products in the utilization of Arenga Pinnata.

As explained in Table 5 that the contribution of product use has a direct relationship with environmental functions. Based on the model presented in Figure 1, it can be seen that the use of products to all elements of *Arenga Pinnata* produces conditions that do not damage the environment and without waste that damages the ecosystem. In addition, the existence of *Arenga Pinnata* in terms of environmental functions also supports economic use and environmental sustainability. The environmental function of *Arenga Pinnata* is capable of being a landslide barrier with root strength and the ability to grow on cliffs (according to the uniqueness of the research location). The sample also felt *Arenga Pinnata*'s ability to maintain Hydrological Cycle Regulation as an ability other commodity crop did not have.

There are pretty exciting findings in the sample, where the welfare of *Arenga Pinnata* farmers is not directly affected by the economic function. This is evidenced by the exposure of Table 5 with a loading factor value of -0.002 with a p-value of 0.837. This indicates that the level of welfare of *Arenga Pinnata* farmers is not affected by product processing directly but is moderated by the environmental function of *Arenga Pinnata*. In other words, the use of environmental functions from *Arenga Pinnata* can improve the welfare of farmers. This finding can be interpreted as processing *Arenga Pinnata* with an environmentally friendly concept that can improve the welfare of farmers. The farmers' welfare that has increased from the significant environmental-based processing of *Arenga Pinnata* is the improvement in nutrition, health, and education of the farmer's family.

Table 4. The value of the latent variable loading factor model

Latent	Indicator	Estimate	Std. Error	z-value	p	Standardized		
						All	LV	Endo
ECF	ECF_AP	1	0			1.002	1.248	1.002
	ECF_PC	0.539	0.08	6.709	< .001	0.618	0.673	0.618
	ECF_AS	0.824	0.074	11.077	< .001	0.876	1.028	0.876
EF	EF_FC	1	0			0.597	0.414	0.597
	EF_RL	1.596	0.223	7.156	< .001	0.997	0.661	0.997
	EF_HC	1.052	0.209	5.04	< .001	0.59	0.436	0.59
	EF_PB	-0.09	0.169	-0.534	0.594	-0.055	-0.037	-0.055
	EF_NB	-0.145	0.165	-0.877	0.381	-0.091	-0.06	-0.091
FW	FW_ES	1	0			0.991	0.657	0.991
	FW_WE	0.236	0.106	2.216	0.027	0.223	0.155	0.223
	FW_HN	0.668	0.091	7.309	< .001	0.605	0.439	0.605
	FW_FH	0.668	0.094	7.111	< .001	0.594	0.439	0.594
	FW_FE	0.788	0.071	11.04	< .001	0.756	0.517	0.756
	FW_SL	0.26	0.158	1.645	0.1	0.168	0.171	0.168
	FW_SC	0.14	0.092	1.524	0.127	0.156	0.092	0.156
MP	MP_neera	1	0			0.681	0.483	0.681
	MP_fruit	1.175	0.167	7.043	< .001	0.819	0.567	0.819
	MP_leaf	-0.034	0.16	-0.213	0.831	-0.023	-0.016	-0.023
	MP_midrib	0.942	0.152	6.216	< .001	0.71	0.455	0.71
	MP_fiber	1.016	0.169	5.999	< .001	0.682	0.491	0.682
	MP_stick	0.851	0.144	5.897	< .001	0.67	0.411	0.67
	MP_sago	1.059	0.158	6.686	< .001	0.771	0.512	0.771
	MP_stem	0.152	0.121	1.25	0.211	0.136	0.073	0.136
	MP_root	-0.125	0.202	-0.619	0.536	-0.067	-0.06	-0.067

Although there is no significant direct impact from the processing of Arenga Pinnata products on the welfare of farmers, the optimization of environmental functions from Arenga Pinnata has become the dominant factor in improving welfare, as described in Table 5. Exploring this impact aspect is also proven by empirical findings, which show that farming communities Arenga Pinnata cultivates after seeing the environmental impact of this plant. Farmers utilize the products produced by Arenga Pinnata with environmentally-based processing. In the end, this condition will impact the welfare of farmers in the form of improving education, health, nutrition, and household needs.

Table 5. Coefficient of estimate regression model between variables

Predictor	Outcome	Estimate	Std. Error	z-value	p	Standardized		
						All	LV	Endo
MP	ECF	0.187	0.284	0.657	0.511	0.072	0.072	0.072
	EF	0.695	0.139	5.005	< .001	0.810	0.810	0.810
ECF	EF	0.022	0.023	0.985	0.324	0.068	0.068	0.068
EF	FW	1.530	0.225	6.801	< .001	0.965	0.965	0.965
MP	FW	0.058	0.068	0.857	0.391	0.043	0.043	0.043
ECF	FW	-0.002	0.009	-0.205	0.837	-0.003	-0.003	-0.003

Although there is no direct impact of Arenga Pinnata's multi-products on improving farmers' welfare and economic function, the modification indices (MI) analysis can find revisions to the direction of the model to produce optimal output. Based on Table 6, it can be seen that several modifications need to be made to obtain the welfare condition of farmers. The modification is related to optimization through a direct relationship between the processing of fruit products from Arenga Pinnata and farmers' welfare to produce an MI of 10,815. The most significant optimization model to improve farmers' welfare is to improve the environmental function of the Arenga Pinnata plant. This indicates that with guaranteed soil conditions from landslides (EF_RL), floods (EF_FC), and Hydrological Cycle Regulation (EF_HC), the welfare of farmers will also be better. In addition, the production of the Arenga Pinnata plant will also be more optimal with modifications to the model.

Product modification from Arenga Pinnata plants will be optimal if farmers pay attention to the consumption pattern of economic stability (FW_ES), family health nutrition (FW_FH), and housing needs (FW_HN). The improvement of environmental functions is also not much different from optimizing product modification, namely by increasing the economic stability of farmers and housing needs. In addition, to improve the environmental function of Arenga Pinnata plant production, it is also necessary to pay attention to the level of education of farmers (FW_FE).

Table 6. Modification indices of Model

	Variable	mi	epc	sepc (lv)	sepc (all)	sepc (nox)
FW	≈ EF_RL	52.542	-34.244	-22.491	-33.888	-33.888
FW	≈ EF_HC	29.925	24.267	15.939	21.569	21.569
FW	≈ EF_FC	23.627	20.138	13.226	19.046	19.046
FW	≈ MP_fruit	10.815	0.546	0.359	0.518	0.518
MP	≈ FW_ES	76.364	-1.676	-0.809	-1.221	-1.221
MP	≈ EF_RL	54.084	-2.091	-1.01	-1.522	-1.522
MP	≈ FW_FH	33.731	1.583	0.764	1.035	1.035
MP	≈ FW_HN	32.712	1.516	0.732	1.01	1.01
MP	≈ EF_HC	31.761	1.497	0.723	0.979	0.979
MP	≈ EF_FC	23.691	1.208	0.583	0.84	0.84
EF	≈ FW_ES	64.904	39.638	16.429	24.776	24.776

EF	=~	FW_FH	32.155	-39.618	-16.42	-22.242	-22.242
EF	=~	FW_HN	31.353	-38.047	-15.769	-21.751	-21.751
EF	=~	FW_FE	14.395	-20.127	-8.342	-12.197	-12.197

The physical and cultural potential in rural areas (especially in the research area) is the main factor as a hinterland or staple-producing area in urban areas. The area studied is a rural area with low potential with infertile agricultural areas, rough topography (hills), and water sources that depend on rainfall. With the cultivation of *Arenga Pinnata*, there is an increase in water availability for household needs. In addition, the various products of the *Arenga Pinnata* plant become an economic attraction for the community.

Based on the data analysis and modification of the model that has been stated previously, for optimizing the model in realizing environmental, economic development in rural areas based on the multi-product *Arenga Pinnata* plant. The *Arenga Pinnata* production center was initiated as a leading sector for various industrial businesses. This effort is a form of downstream *Arenga Pinnata* products that pays attention to the economic value of plants and environmental values (Ansar, Nazaruddin, Azis, et al., 2021; Haryoso et al., 2020). Products from the *Arenga Pinnata* plant will produce industrial units to improve environmental sustainability and increase farmers' welfare. In addition, downstream of *Arenga Pinnata* plant products will be able to absorb labor and improve the regional economy in producing center areas in the short term, and will also be able to increase economic variability nationally.

Following the model that shows that farmers' welfare can be increased by improving the environmental function of *Arenga Pinnata*. The downstream process of *Arenga Pinnata* plants will pay attention to environmental impacts first to contribute to local, regional and sectoral economic improvements. The extended downstream of the *Arenga Pinnata* plant will open up product diversification that opens up job opportunities (Pro Job), reduces poverty and unemployment (Pro-Poor), reduces the impact of environmental damage (Pro Environment), and improves people's welfare (Pro-Growth).

Conclusion

Optimization of *Arenga Pinnata* plant processing through product downstream is one alternative in preserving the environment and significantly reducing the impact of environmental damage. Policies for *Arenga Pinnata* cultivation by following the environment-based economic welfare development model can also increase employment and reduce poverty. The ability of the *Arenga Pinnata* plant to produce a variety of products and, at the same time, improve environmental functions can be an effective model in improving the welfare of the community in the environment, both locally, regionally, and sectorally.

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