Designing Model for the Development of Sustainable Small Coffee Agroindustry at the Agropolitan Area of Ijen, East Java, Indonesia

by Danu Indra Wardhana

Industria: Jurnal Teknologi dan Manajemen Agroindustri
Volume 12 No 1: 45-59 (2023)

Industria: Jurnal Teknologi dan Manajemen Agroindustri
http://www.industria.ub.ac.id
ISSN 2252-7877 (Print) ISSN 2548-3582 (Online)
https://doi.org/10.21776/ub.industria.2023.012.01.5

Designing Model for the Development of Sustainable Small Coffee Agroindustry at the Agropolitan Area of Ijen, East Java, Indonesia

Desain Model Pengembangan Agroindustri Kopi Rakyat Berkelanjutan di Kawasan Agropolitan Ijen, Jawa Timur, Indonesia

Danu Indra Wardhana[1]*, Yuli Wibowo[2], Sony Suwasono[2]
[1]Department of Agroindustrial Technology, Faculty of Agriculture, University of Muhammadiyah Jember,
Jl. Karimata No.49, Jember, 68121, Indonesia
[2]Department of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Jember,
Jl. Kalimantan 37 Jember, 68121, Indonesia
*danuindra@unmuhjember.ac.id
Received: 29th May, 2022; 1st Revision: 05th January, 2023; 2nd Revision: 09th February, 2023; Accepted: 17th July, 2023

Abstract

Considering Indonesia is one of the world's major coffee producers, the small coffee agroindustry has much room to grow. The industry faces some challenges, including low output, limited access to the market, insufficient human resource capabilities, and improper waste treatment. This research aimed to create a model for the coffee agroindustry's growth utilizing a sustainable development concept in the form of decision support systems. The model is named AgroCoffee, which comprises six submodels: submodel of superior product selection of coffee agroindustry, submodel of social, submodel of institutional, submodel of technology, submodel of environmental, and submodel of economic. This study used several data analysis methods: exponential comparison approach, multi expert-multi criteria decision-making, interpretative structural modeling, analytical hierarchy process, and financial analysis. The model was verified in the agropolitan area of Bondowoso's Ijen highland in East Java, Indonesia. The findings revealed that the model could accurately simulate the coffee agroindustry system, which allows the model to generate recommendations for decision-makers on how to establish sustainable coffee agroindustry. Further improvements and adjustments to the model need to be conducted to develop a better model that dynamically follows the current needs and conditions to make the latest data and information obtained more accurate.
Keywords: coffee agroindustry, Ijen highland agropolitan, sustainable development

Abstrak

Indonesia merupakan salah satu penghasil kopi terbesar di dunia sehingga agroindustri kopi rakyat berpotensi tinggi untuk dikembangkan. Permasalahan pengembangan agroindustri kopi rakyat di Indonesia yaitu: produktivitas kopi yang rendah, akses pemasaran yang terbatas, keterampilan sumber daya manusia yang rendah, dan limbah pengolahan kopi yang belum ditangani dengan baik. Penelitian ini bertujuan untuk merancang suatu model pengembangan agroindustri kopi rakyat dengan menggunakan konsep pembangunan berkelanjutan dalam bentuk sistem penunjang keputusan. Model ini diberi nama AgroCoffee, yang terdiri dari 6 submodel, yaitu submodel pemilihan produk unggulan, submodel sosial, submodel kelembagaan, submodel teknologi, submodel lingkungan, dan submodel ekonomi. Metode yang digunakan dalam analisis terdiri dari metode perbandingan eksponensial, multi expert-multi criteria decision making, interpretative structural modeling, analytical hierarchy process*, dan analisis finansial. Rancangan model disimulasikan pada Kawasan Agropolitan Dataran Tinggi Ijen Kabupaten Bondowoso, Jawa Timur, Indonesia. Hasil penelitian menunjukkkan bahwa rancangan model telah mampu mensimulasikan sistem agroindustri kopi rakyat berdasarkan hasil verifikasi dan validasi pada model AgroCoffee. Oleh karena itu, model dapat diterapkan untuk memberikan rekomendasi bagi para pengambil keputusan dalam pengembangan agroindustri kopi rakyat yang berkelanjutan. Penyempurnaan dan penyesuaian model perlu dilakukan dalam rangka pengembangan sistem yang sesuai dengan kebutuhan dan kondisi saat ini sehingga data dan informasi terbaru yang diperoleh lebih akurat.*
Kata Kunci: *agroindustri kopi, agropolitan dataran tinggi Ijen, pembangunan berkelanjutan.*

INTRODUCTION

Coffee is a commodity with significant economic impacts in Indonesia. Such impacts contribute to earning foreign exchange, job availability, and revenue for coffee growers and other economic players involved in the growing, processing, and marketing chain (Widyotomo, 2013; Hariance et al., 2015). According to data from the Indonesian Ministry of Agriculture's Directorate General of Estate Crops, Indonesia is one of the world's largest coffee producers, with a total production of 760,960 tons in 2019 and predicted to climb to 777,730 tons in 2024 (Widaningsih, 2020). As it has enormous prospects for domestic and international markets, the coffee agroindustry in Indonesia is potentially developed. Unfortunately, due to low coffee productivity, limited access to markets, family style of management, limited skilled human resources, and the low quality of coffee produced, the coffee agroindustry is facing quite complex challenges today. The before and after-harvest challenges and market issues raise serious concerns about the coffee industry's long-term viability, especially given the world's dynamic customer base (Putri et al., 2018; Novita et al., 2012).

In addition, the diversity of coffee products and waste generated during coffee processing are also posing a concern for the coffee agroindustry's long-term viability. Since they are produced using straightforward procedures and equipment, blended with water and other components in relatively large quantities, most processed agroindustry products only contain low-quality coffee beans (Murthy & Madhava Naidu, 2012). The profit from the coffee agroindustry heavily relies on selling coffee beans, considered low-value items. This circumstance may force entrepreneurs and coffee farmers to run their other businesses to be more profitable and provide better-added value, putting the coffee agroindustry's economic sustainability at risk. Narulita et al. (2014) stated that to increase value, competitiveness, and local consumption, the domestic coffee agroindustry should concentrate not only on primary products such as coffee beans but also on processed products.

Lack of knowledge and awareness of standard operating procedures for coffee and waste processing can jeopardize the coffee agroindustry's environmental sustainability by causing waste and pollution to build up in the surroundings. For that reason, to keep ecosystems and environmental balance, appropriate waste handling technology is essential to decrease the impact of collected waste. Because of the intricacy of these issues, the sustainability of the coffee agroindustry must be evaluated because it encompasses a wide range of issues and concerns that must be addressed. Azhar et al. (2021) used the Exponential Comparison Method (MPE) to determine superior agro-industrial products. Jaya et al. (2011) used Interpretive Structural Modeling (ISM) and Multi Experts Multi-Criteria Decision Making (MEMCDM) methods to improve the institutional system and quality of Gayo coffee. Fadhil et al. (2018) applied the Interpretive Structural Modeling (ISM) method in formulating the Gayo coffee agroindustry development strategy. Lamefa et al. (2020) formulated a strategy for developing coffee agroindustry using the SWOT and Analytical Hierarchy Process (AHP). Simatupang et al. (2022) researched added value analysis and strategies for developing the ground coffee agroindustry using a business feasibility analysis and the SWOT method. Currently, the models for developing the smallholder coffee agroindustry using a sustainable development approach are limited. As a result, it is necessary to create a sustainable coffee agroindustry growth model that employers and coffee farmers may utilize as a guide to help them grow their businesses.

This research aims to create a coffee agroindustry development model incorporating sustainable development concepts into decision support systems. The main goal of this study is to improve agroindustry competitiveness. The issues confronting today's industry development are not only economic but also environmental and social. The model of sustainable development in the coffee agroindustry proposed in this study may be helpful to policymakers as an insight into developing coffee agroindustry, particularly in regions promoting coffee agroindustry for economic development.

METHODS

With the system's complexity, the coffee agroindustry development requires a coffee agroindustry system modeling. The final model in this research should offer equal advantages to the coffee agroindustry, including farmers, business people, local government, and other associated aspects. In addition, it is also expected to produce coffee agroindustry products that are reliable, efficient, resilient, inclusive, and environment friendly. Figure 1 depicts this study's framework for constructing a sustainable coffee agroindustry development model. The problem-solving methodology utilizing a systems approach was referred to as the stages of study (Eriyatno, 2012). This study was conducted systematically and logically in four stages below:

Preliminary Study

A preliminary study was the first stage that involved a review of related literature, field research, and an expert survey. The preliminary study was conducted in Bondowoso Regency, East Java Province. Literature from numerous sources and references were reviewed to provide a theoretical framework. Field observation was conducted in locations that could develop into sustainable coffee agroindustry. The findings were used to create a sample of agroindustry to implement the model. Experts were chosen for the surveys based on their qualifications and the number of experts needed for the research. Lecturers, researchers, government officials, and agroindustry practitioners were the research experts.

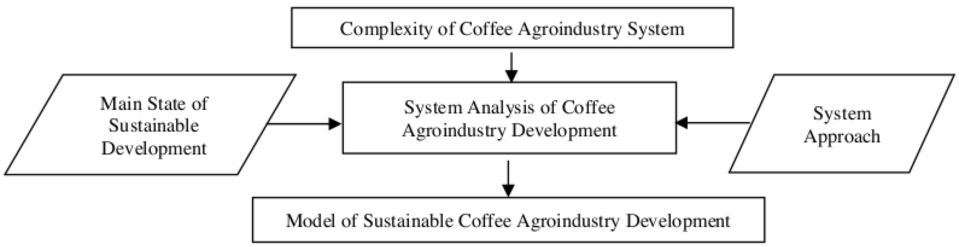

Figure 1. The Study Framework (Wibowo et al., 2011)

System Analysis

System analysis aims to summarize the coffee agroindustry system designed in this study, including needs assessment, problem statements, and system identification. The needs assessment defined the requirements for several components of the coffee agroindustry system. The problem statements underlined challenges faced by coffee agroindustry systems for system development. System identification was then carried out to summarize the systems using a circumference diagram causal effect before moving on to the input-output chart.

System Modeling

Based on the characteristics analysis of the coffee agroindustry system, system modeling plans to create a sustainable model of the coffee agroindustry. The model is described further in submodels which discuss the elements and dimensions used in modeling sustainable coffee agroindustry systems based on the findings of the system analysis.

Verification and Validation

The computerization process, logical works, and components of substances provided in the model were all evaluated and checked throughout the verification stage (Eriyatno, 2012). Verification aims to discover the program's logical and editorial faults. The face validity technique validated the model (Sargent, 2013). The validation procedure used in this study consisted of constructing questions to ensure that the model comprised all elements, events, and relationships from a coffee agroindustry system.

Data Collection

Two types of data were collected in this research; primary and secondary. Primary data was gathered through empirical observation in the field and information collection from experts via questionnaires or interviews. The experts involved in this research were represented by academics, business actors, and bureaucrats with expertise in technology and management in the coffee agroindustry. The list of experts involved in this research can be seen in Table 1. Secondary data was gathered from the literature to provide a theoretical framework and supplementary data for this study. This data can be obtained from the statistics center, the Bondowoso Regency smallholder coffee agroindustry, government agencies, and related research reports. The information was then analyzed and categorized according to the model's design requirements.

Table 1. The list of experts involved in this research

No.	Name	Institution/Profession
1	Ir. Bambang Sriono	Bondowoso Regency Coffee Farmer
2	Nur Cahyaningrum, S.TP.,	Department of Cooperatives, Industry and Trade Bondowoso Regency
3	Muhammad Malik S.Ag., M.Ag.	Bondowoso Regency Regional Research Council
4	Juli Sapta Rini, S.P.	Bondowoso Regency Regional Development Planning Agency
5	Sigit Dwi Wahju B., S.TP., M.Si.	Department of Agriculture Bondowoso Regency
6	Dr. Ir. Herlina, M.P.	Department of Agricultural Product Technology, University of Jember
7	Djoko Sumarno, S.P., M.P.	Indonesian Coffee and Cocoa Research Institute

RESULTS AND DISCUSSION

System Analysis

Needs Assessment

Needs assessment is essential to analyze the system (Eriyatno, 2012). At this phase, significant effort must be made to locate and fulfill all interests depending on the requirements of each system component. The results of a poll, expert opinion, discussions, or field observation may all be included in this analysis. Table 2 shows the components of the coffee agroindustry development actors and their demands for identification.

Table 2. Needs analysis of the coffee agroindustry development

No.	Actors	Needs
1.	Coffee farmers	a. The selling price is high b. Increased revenue c. Ease of getting business capital d. Productivity increases
2.	Association of coffee farmers	a. Participation of business actors b. Increased group earnings c. A strong network of cooperation
3.	Cooperative	a. The welfare of cooperative members b. Ease in organizing farmers c. Increase in cooperative income d. Market access
4.	Coffee agroindustry	a. Continuity of raw materials b. Increased agroindustry revenue c. Price and quality of suitable raw materials d. Effective and efficient processing technology
5.	Investors	a. Profitable investment b. The investment risk is low c. Fast capital back
6.	Financial institutions	a. Guarantee the smoothness of credit payments b. Increase in customers
7.	Research institutions	a. Conducting product research b. Cooperative relationship benefiting both parties c. Expanding research collaborations with allied agroindustry
8.	Local government	a. Opening job field b. Increased local revenue c. Acceleration of regional development d. The development of related agro-industries

Problem Statement

The coffee agroindustry's growth main issue is that the needs of all parties involved in its long-term development have not yet been met. The challenges faced by the coffee agroindustry sustainability system are: 1. low productivity of the coffee agroindustry, both in terms of quality and quantity; 2. lack of excellent product development of the coffee agroindustry; 3. lack of skilled human resources in technical, technology, and management in operating the agroindustry; 4. limited availability of information, either in terms of process technology, product competitiveness, or advertising, leading to slow growth; 5. the farmers' mindsets and attitudes reluctance to shift from agriculture to industrialization; 6. improperly treated waste causing environmental contamination; and 7. there are no suitable institutions among coffee agroindustry operators.

System Identification

System identification aims to describe the coffee agroindustry systems using a causal effect circumferential diagram, which is then translated into an input-output diagram (Figure 2). This diagram shows the correlation between the input and output of the coffee agroindustry system using the objects depicted in Figure 3 as a black box.

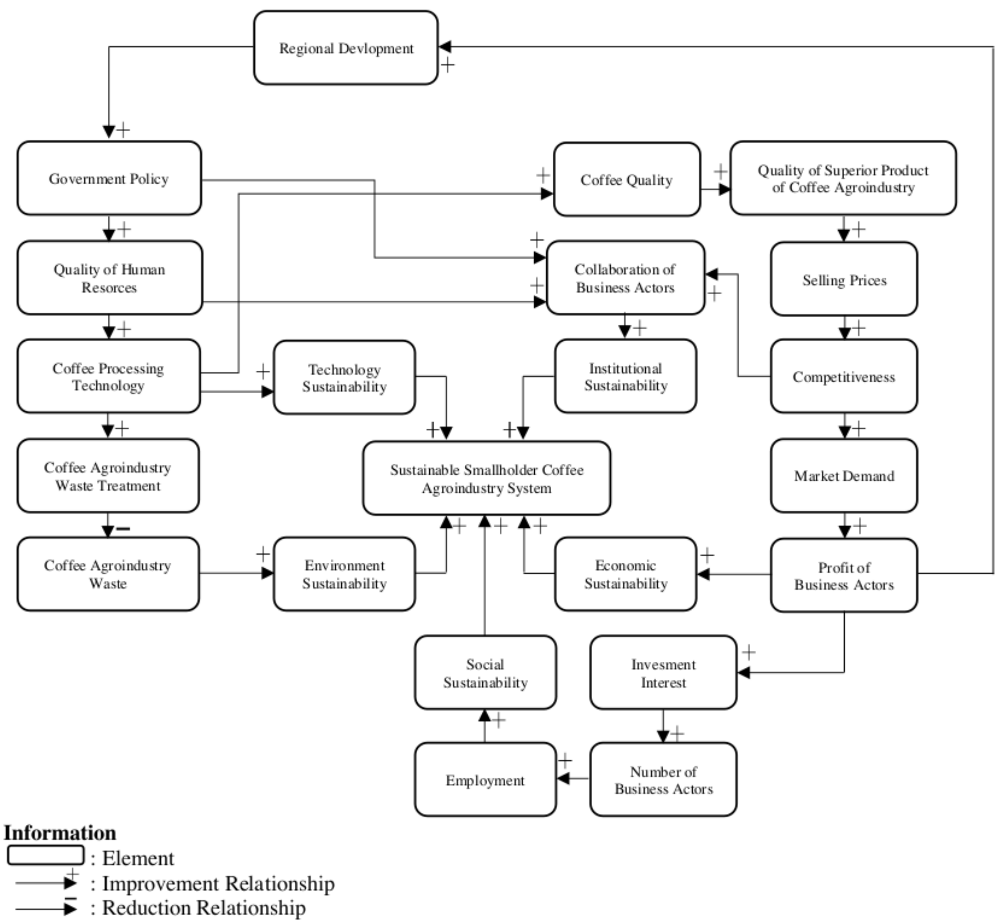

Figure 2. Cause and Effect Circle of Coffee Agroindustry Development System

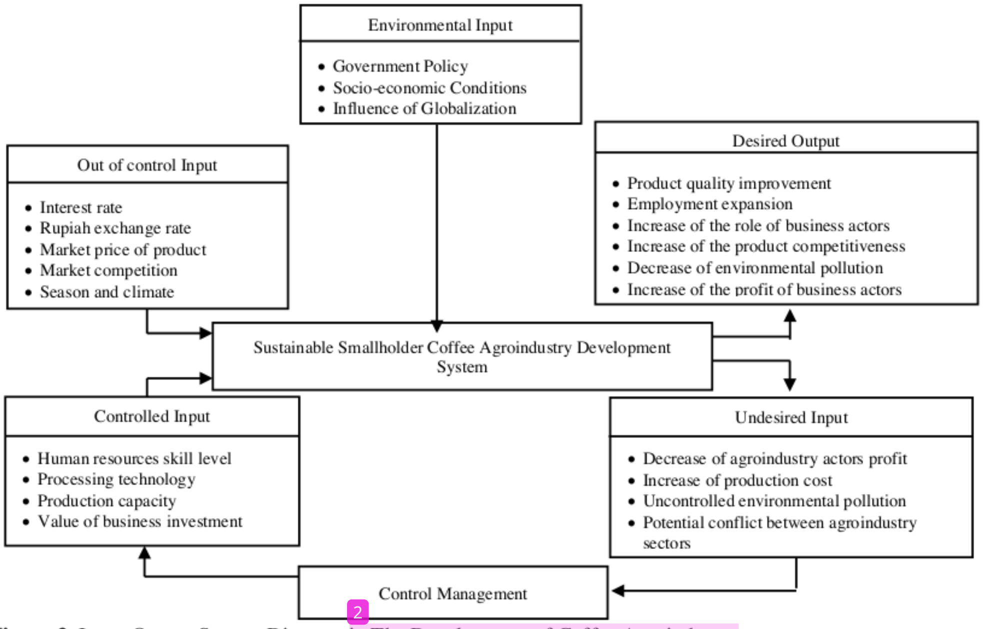

Figure 3. Input-Output System Diagram in The Development of Coffee Agroindustry

Model Configuration

The development of the model of sustainable coffee agroindustry was divided into numerous submodels based on the system analysis (Table 3). The model was created using Decision Support System (DSS) software called AgroCoffee. The model of DSS is a computerized system with three key components: Database Management Systems, Model Management Systems, and Dialogue Management Systems. Figure 4 shows the complete setup of the DSS for creating sustainable coffee agroindustry.

The AgroCoffee model was verified to guarantee that the final model complies with the logical framework and can be used for the intended purpose. As a case study, the existing coffee agroindustry in Bondowoso Regency was used to verify the AgroCoffee model. The implementation findings showed that the model had been correctly verified, and there were issues with transforming conceptual models into mathematical models. So, it demonstrated that the model adhered to the logic framework and could be used to run simulations using a computer program.

Table 3. Structure of agroindustry development model of sustainable coffee

Sub Model	Indicator	Analysis Methods
Selection of excellent products	a. Selection of superior products of coffee agroindustry	Methods of Exponential Comparison (Marimin, 2017)
Social	a. Social feasibility of coffee agroindustry development	Multi Expert-Multi Criteria Decision Making (ME-MCDM) (Zulueta et al., 2013)
Institutional	a. Selection of institutional model of coffee agroindustry	Methods of Exponential Comparison (Marimin, 2017)
	b. The institutional structure of the coffee agroindustry	Interpretive structural modeling (ISM) (Saxena et al., 1992)
Technology	a. Selection of coffee agroindustry processing technology	Analytical Hierarchy Process (AHP) (Saaty, 2008)
Environment	a. Selection of handling waste processing of coffee agroindustry	Methods of Exponential Comparison (Marimin, 2017)
Economics	a. Financial feasibility and sensitivity of coffee agroindustry	NPV, IRR, Net B/C Ratio BEP, PBP and Sensitivity Analysis (Sobana, 2018)

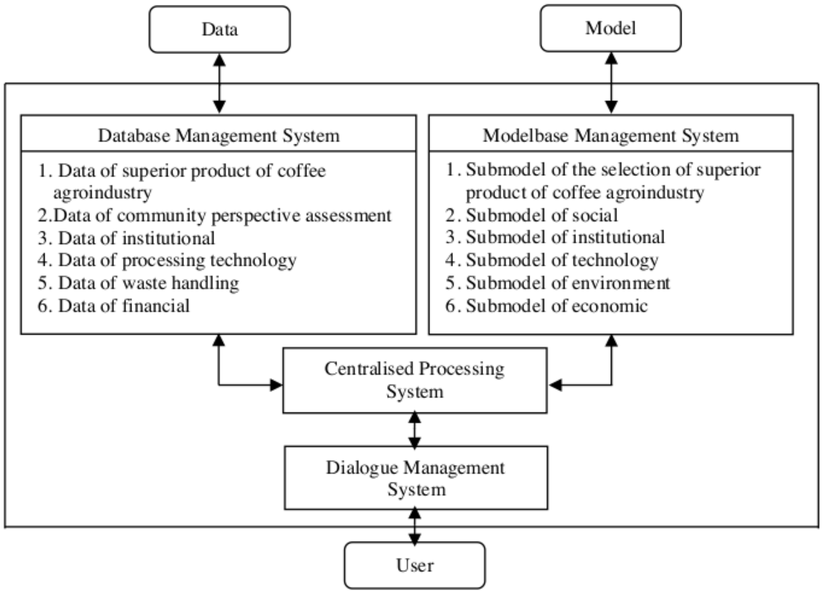

Figure 4. Configuration of DSS Development of Sustainable Coffee Agroindustry

Verification and Validation

AgroCoffee model verification was carried out to ensure that the resulting model followed the logical framework to function according to the expected goals. The AgroCoffee model was verified using the community coffee agroindustry system in Bondowoso Regency as a case study. The implementation results indicated that the model had been adequately verified and showed no problems translating the conceptual model into a mathematical model. So, it showed that the model complied with the logic framework and could perform simulations using computer programs. Structurally validation of the development model of community coffee agroindustry was carried out using face validity through discussions with experts. The validation result showed that the AgroCoffee model followed actual conditions, and the submodels used covered most of the needs to develop a sustainable smallholder coffee agroindustry. The AgroCoffee model was considered quite accurate and significantly supported decision-makers through various easy-to-use analytical facilities. It can be seen from the suitability between the model output and the actual system conditions, indicating that the model developed is valid. The logic of the model developed for each submodel was correct, and the relationship between input-output in the model is considered appropriate.

Overview of the AgroCoffee Model Application

The AgroCoffee model application is an implementation of the development model of a sustainable community coffee agroindustry designed in a computer package named AgroCoffee. This application aims to provide input for entrepreneurs, policymakers, local governments, and related stakeholders who wish to develop a smallholder coffee agroindustry in their area. To access the AgroCoffee model application, open the website address http://www.agrocoffee.amertaproject.com. The user must fill in the identity on the login menu according to the system's request to authenticate the user. The AgroCoffee model application access dialog can be seen in Figure 5.

After the user authentication process is complete, the application program will display the dashboard page. This page contains the main menu contained in the AgroCoffee model application. The display of the AgroCofee model application dashboard page is presented in Figure 6. The AgroCoffee model application consists of 6 submodels: superior product selection submodel, social submodel, institutional submodel, technology submodel, environmental submodel, and economic submodel. The appearance of the AgroCoffee model application structure can be seen in Figure 7.

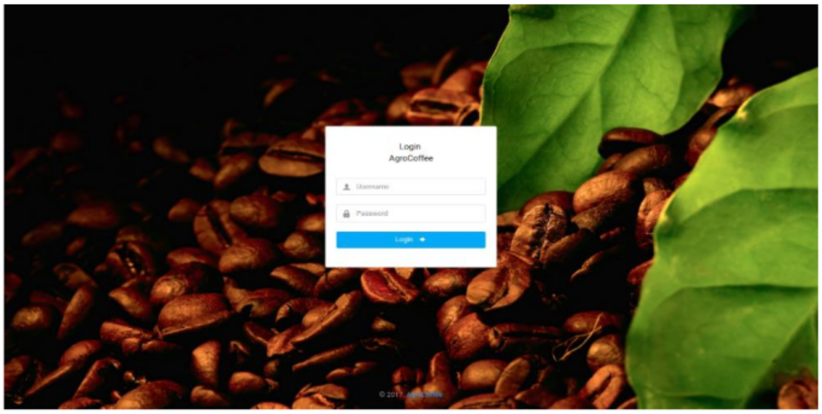

Figure 5. AgroCoffee Model Application Access Dialog

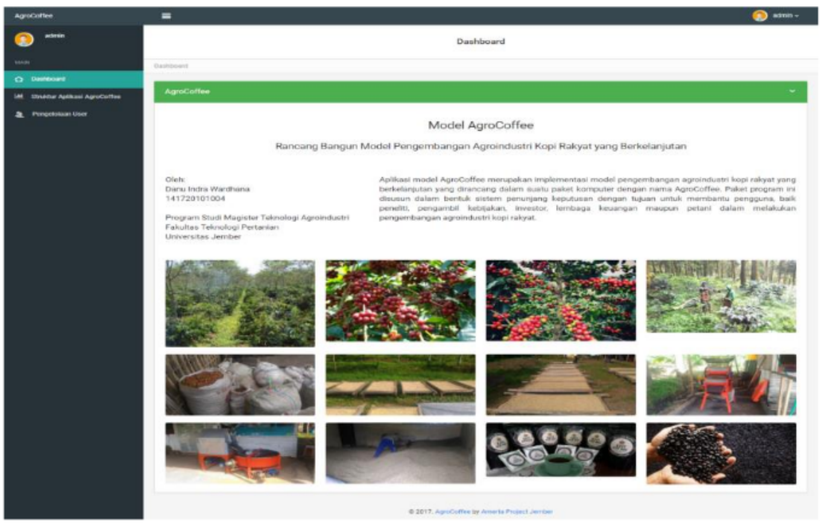

Figure 6. AgroCoffee Model Application Dashboard Page

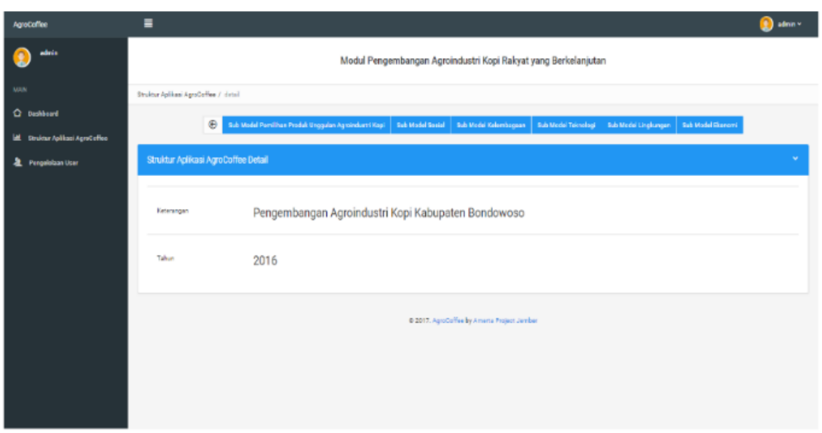

Figure 7. AgroCoffee Model Application Structure

Model Implementation

Featured Product Selection Submodel

Production costs, technology in use, employment, value contributed, market opportunities, environmental impact, public policy, and public approval were used to select featured products. Table 4 presents the analysis results, which included coffee product selection using the MPE technique. Instant coffee was the most important result of the coffee products chosen as it has a high added value, a large market, and a low environmental impact. Furthermore, instant coffee is popular among others due to its lower price and a more straightforward manufacturing procedure.

Table 4. The result an alternative assessment of coffee bean products

No	Product	Weight	Priority
1	Powdered coffee	10,298,393.58	2
2	Instant coffee	11,893,038.26	1
3	Herbal coffee	5,961,116.12	4
4	Coffee dip	3,431,276.11	8
5	Low-caffeine coffee	4,001,659.24	7
6	Coffee in packages	6,332,175.34	3
7	Roasted coffee beans	5,278,244.75	5
8	Coffee beans hard skin (HS)	2,318,067.85	9
9	Coffee beans wet process (WP)	1,974,944.24	10
10	Coffee beans dry process (DP)	4,115,414.19	6
11	Pumpkin coffee beans	1,710,369.50	11

Social Submodel

The social submodel aims to determine the social feasibility of developing the instant coffee agroindustry. To execute this submodel, expert assessment data, either in the form of weight or score data, was used based on preset social eligibility criteria (Table 5). The findings of this submodel implementation revealed that the regency's instant coffee agroindustry development was at a "Medium" level or reasonably practicable. This was backed by ideal socio-cultural conditions and community support, earning the instant coffee agroindustry a "High" rating. Moreover, the indicator of linked stakeholder support received a "High" rating. This suggests that the growth of the coffee agroindustry should get total support from essential stakeholders for the instant coffee agroindustry to function optimally afterward.

Table 5. Assessing the feasibility of a social perspective instant coffee agroindustry development

No	Criteria	Weight	Negation	Index value	Negation v index value
1	Community support	H	L	H	H
2	Support of relevant stakeholders	H	L	H	H
3	Social and cultural conditions of local communities	H	L	M	M
4	Society participation	H	L	M	M
5	People's motivation	H	L	M	M
6	The ability of community human resources	M	M	M	M
Aggregation		**M "Medium"**			

Institutional Submodel

The institutional submodel aims to identify an appropriate alternative institutional model for planning a sustainable coffee agroindustry development and to structure the selected institutional development. Competition, access to the market, advantages, continuation rates, access to finance, efficiency, manageability, and information access are among the factors used to evaluate alternative institutional arrangements. The evaluation of different institutional models in the coffee agroindustry revealed that the institutional business group was the best option, with a value of 3,819,234.99 (Table 6).

Table 6. The result of an alternative assessment of institutional coffee agroindustry

No	Institutional Model	Weight	Priority
1	Strategic partnership	913,043.18	5
2	The nucleus of plasma	1,662,405.13	3
3	Trading in general	634,580.82	6
4	Agribusiness operations	447,605.16	7
5	Patterns of network	1,798,949.10	2
6	Agroindustry collaboration	1,200,084.34	4
7	Business associations	3,819,234.99	1
8	Independent business	73,608.34	8

The business association is a development inside a group that assists in organizing business activities and on-the-go efforts in one or more activities. The establishment of the instant coffee agroindustry should be done in connection with implementing the business group, according to the outcomes of the institutional election process. This model can combine and synergize the small forces that make the coffee agroindustry into a more significant force.

Following the next round of institutional selection, the factors that played a crucial part in the coffee agroindustry's institutional development were organized. Factors of development goals, development needs, development partners, development limitations, and development activities are among the system's elements examined. Expert advice and parties involved in the growth of the coffee agroindustry were used to construct the elements development system. The structuring of all elements in the development of the coffee agroindustry produced an essential factor in each of the sub-elements (Figure 8).

Each of the structuring aspects of the coffee agroindustry development has sub-important factors. Improving the quality, productivity, and market access are the important sub-elements in the objective element, followed by improving the quality of human resources. The other essential sub-elements are competent human resources in the needs element, low-quality human resources in the constraint element, coffee farmers in the actors' element, and enhancing the quality of human resources in the activity element. The coffee agroindustry's institutional development depends on these six major sub-elements.

Objectives, needs, constraints, and development activities all point to a greater emphasis on the need for qualified human resources. Based on this, offering training for human resources in the instant coffee agroindustry is vital to run the agroindustry efficiently and generate high-quality processed products, hence boosting the agroindustry's competitiveness. It also addresses other essential sub-elements of the objective of promoting quality, productivity, and market access.

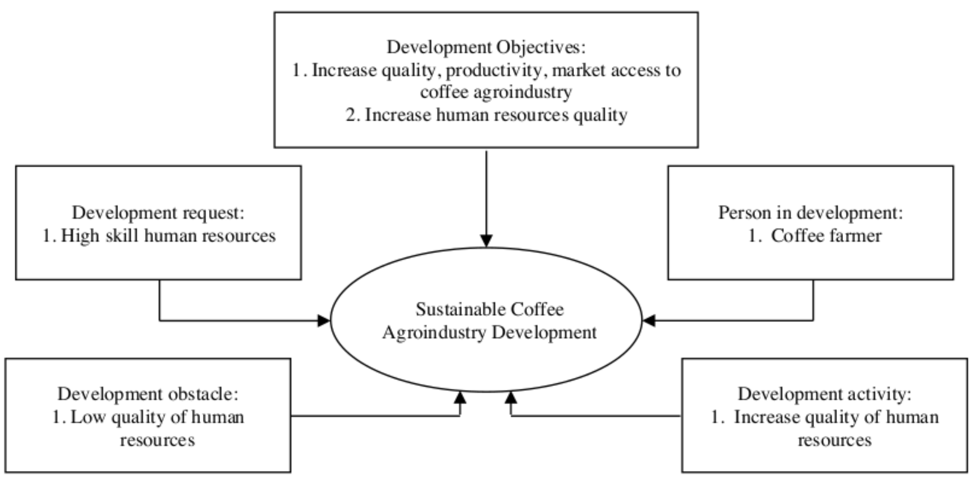

Figure 8. Structure of Key Element of Coffee Agroindustry Development

Farmers are a sub-key element in the element actors due to the farmer's role as a raw material producer and a starting point for the instant coffee agroindustry. The availability of raw materials may influence the quality of instant coffee. Furthermore, coffee farmers earn the least in the value chain of commercial activities, making them the primary actors who should receive more attention as the instant coffee agroindustry develops.

Technology Submodel

The technology submodel aims to choose an acceptable coffee processing method to develop a long-term coffee business. Dry processing, wet processing, and semi-wet processing are all options for processing technology. The factors utilized to identify the priority alternative in technology selection include simplicity of operation, yield quality, operational cost, and environmental impact (Table 7).

Table 7. Priority for coffee agroindustry processing technology selection

No	Alternative	Criteria				Synthesis	Priority
		Ease of Operation	Quality Results	Operating Costs	Environmental Impact		
1	Dry processing	0.696	0.080	0.712	0.490	0.340	2
2	Wet processing	0.147	0.655	0.140	0.199	0.429	1
3	Semi-wet processing	0.157	0.265	0.148	0.312	0.231	3

Wet processing takes precedence over the other two options since the quality of the results achieved is superior. Consequently, compared to other processing methods, the selling price for wet coffee processing items will be higher. Dry processing is the second option that can be chosen since it is the simplest to process, has the lowest running costs, and produces the least waste.

Environmental Submodel

The environmental submodel aims to establish an alternative waste management system for the coffee agroindustry. This submodel addresses waste issues in the coffee business, such as solid and liquid waste. The running costs, simplicity of operation, benefits, environmental implications, and added value of alternative methods for treating solid and liquid waste are all based on the same criteria (Tables 7 and 8).

Organic compost is the most essential alternative solid waste management option (Table 8). Due to the abundance of raw materials for composting in coffee estate crops, an alternative organic compost was chosen. The skin of coffee fruit can be made directly into organic compost (Afrizon, 2015; Novita et al., 2018). Furthermore, this organic compost can be reused as coffee plant compost, potentially increasing coffee plant fertility.

Table 8. Result of the assessment of solid waste management alternatives

No	Product	Weight	Priority
1	Organic compost	4,349,691.63	1
2	Animal feed	2,499,828.52	3
3	Activated charcoal	1,553,693.02	6
4	The raw material of bioethanol	1,516,937.71	7
5	Liquid smoke	862, 201.50	9
6	Particle board	2,467,509.54	4
7	Ameliorant ground	2,248,988.59	5
8	Growing media	3,494,885.32	2
9	Beverage raw materials	460,683.76	12
10	Sources of raw material liquid sugar	413,038.98	13
11	Briquettes	1,388,094.02	8
12	Biodiesel feedstock	721,840.98	10
13	Media protein production	515,228.50	11

Liquid fertilizer (Table 9) is the highest priority alternative wastewater treatment option, as it may utilize the raw ingredients of liquid waste from the coffee processing process, either from the washing or fermenting process. Liquid fertilizers provide several benefits, including ease of administration, the presence of microorganisms not found in solid organic fertilizers, and nutrients that plants more easily take (Analianasari et al., 2022; Rochmah et al., 2021).

Table 9. Result of the assessment of waste water treatment alternatives

No	Product	Weight	Priority
1	Liquid fertilizers	3,814,794.53	1
2	Liquid pesticides	2,470,881.21	3
3	Raw materials biogas	2,936,448.56	2
4	Reuse of wastewater	963,950.01	4

Economic Submodel

The economics submodel aims to examine the financial viability of the instant coffee agroindustry. Some measures were employed in the feasibility study, including Net Present Value (NPV), Net/Benefit-Cost Ratio (Net B/C), Pay Back Period (PBP), and the Internal Rate of Return (IRR) (Sobana, 2018). Table 10 shows the assumptions in the feasibility analysis, and Table 11 shows the analysis outcomes.

According to the financial feasibility analysis, the project's net present value (NPV) in US dollars is USD 493,123. These findings could show that the instant coffee agroindustry's 10-year net profit is USD 493,123. This attempt has an NPV larger than zero, indicating that this enterprise is viable. Calculating the net B/C ratio is another analytical tool that may be used to evaluate the appropriateness of the requirements for a firm to operate. A net B/C ratio of greater than one indicates that the business can be carried out, while a net B/C ratio of less than one indicates that the business cannot be carried out. Based on the findings, the net B/C ratio is 1.14, which indicates that the instant coffee agroindustry generates a net benefit of 1.14 times the total costs invested.

Table 10. Assumptions of financial feasibility analysis of instant coffee agroindustry

No	Descriptions	Unit	Amount
1	Production per day	Kg	412
2	Number of working days	Day	26
3	Months of work per year	Month	12
4	Production per year	Kg	128,544
5	Bank interest	%	9.75
6	Start-up capital	USD	196,532
7	Capital loan	USD	458,576
8	Prices of products	USD	4.90
9	The variable cost per product	USD	2.80
10	Gross revenue	USD	627,580
11	Earnings before interest and taxes	USD	185,469
12	The project's economic lifespan	Year	10
13	Repayment term for a loan	Year	10

1 USD = 14,3377.75 IDR, 1 IDR = 0.000070 USD

Table 11. Result of financial analysis of instant coffee agroindustry

No	Description	Unit	Amount
1	Net Present Value (NPV)	USD	493,123
2	Internal Rate of Return (IRR)	%	48.49
3	Net B/C Ratio	-	1.14
4	Break Event Point (BEP)	Kg	39,301
5	Payback Period (PBP)	Year	3.53

1 USD = 14,337.75 IDR, 1 IDR = 0.000070 USD

The IRR figure calculates the annual profit percentage or a company's ability to repay bank interest. When the NPV is zero, the IRR equals the interest rate (*discount factor*). Before being interpolated, the IRR is calculated by determining the positive and negative NPV values. If the IRR > than the bank rate, the effort is worthwhile. However, the effort is not worthwhile if the IRR < the bank rate. The analysis findings show that the IRR for instant coffee is 48.49 percent, more significant than the bank interest rate of 5.0 to 9.7%, implying that the agroindustry investment is still lucrative.

The analysis Break Even Point (BEP) calculates the minimum production capacity to be created. BEP analysis, also known as break-even analysis, may determine when the cost is the same (Oka et al., 2021). The calculation of the coffee agroindustry break-even revealed a minimum annual production of 39,301 Kg. This amount is smaller than the planned production capacity, indicating that it is worthwhile to make an effort. The time it takes to return the initial investment is known as the payback period. The payback period of this investment is over 3.53 years, according to the results of this project's estimates, which indicates that the investment will be repaid in the fourth year of the investment's life.

A sensitivity analysis of the financial feasibility of the instant coffee agroindustry employed six scenarios, including a 10%, 20%, and 30% increase in raw material prices, followed by a 5%, 10%, and 15% fall in selling price. (Table 12). The sensitivity analysis of financial feasibility utilizing increases in raw material prices of 10%, 20%, and 30% clearly shows that the option is still worthwhile. Furthermore, sensitivity analysis utilizing 5% and 10% price reductions shows that the option is worthwhile. However, a 15% decrease in product selling prices reveals that the decision is not viable.

Table 12. Sensitivity analysis of financial feasibility instant coffee agroindustry

Eligibility Criteria	NPV	IRR	Net B/C Ratio	BEP	PBP	Decision
Raw materials price up 10%	USD. 324,255.70	36.49%	1.09	43,007	4.17	Feasible
Raw materials price up 20%	USD. 170,494.69	24.24%	1.05	47,483	5.03	Feasible
Raw materials price up 30%	USD. 16,733.67	11.25%	1.004	53,000	6.22	Feasible
Selling price down 5%	USD. 289,088.75	33.84%	1.09	44,532	4.25	Feasible
Selling price down 10%	USD. 100,165.36	18.55%	1.03	51,369	5.34	Feasible
Selling price down 15%	USD. -88,771.25	1.05%	0.97	60,686	7.17	Not feasible

CONCLUSIONS

Designing a model for the sustainable development of the small coffee agroindustry produces a decision support system called AgroCoffee. The system can be used as decision support in developing the small coffee agroindustry. The AgroCoffee decision support system consists of several submodels, namely the submodel of selecting the superior products of the coffee agroindustry, which results in recommendations for instant coffee as a product that is feasible to develop; the social submodel produces a feasible assessment for the development of instant coffee agroindustry in Bondowoso Regency; the institutional submodel produces recommendations for business group partnerships that are suitable for implementation in the development of instant coffee agroindustry with the results of structuring the development elements. The environmental submodel produces recommendations for handling solid waste to be used as organic compost and liquid waste to be used as liquid fertilizer, and the economic submodel provides financial feasibility analysis results indicating that instant coffee agroindustry is feasible to develop with a maximum sensitivity analysis limit on a 10% reduction in product selling prices. Further improvements and adjustments to the model need to be done to develop a better and more up-to-date system following current needs and conditions. Therefore, it is necessary to support an integrated management information system, both manual and computer-based, to make the updated data and information obtained more accurate.

ACKNOWLEDGMENTS

The authors would like to thank the LPPM-University of Jember for the support of this experiment under Reworking Scheme No. 18382/UN25/LT/2019-2020.

References

Afrizon. (2015). Potensi kulit kopi sebagai bahan baku pupuk kompos di Propinsi Bengkulu. *AGRITEPA: Jurnal Ilmu Dan Teknologi Pertanian*, *2*(2), 21–32. https://doi.org/10.37676/agritepa.v2i2.179

Analianasari, A., Kenali, E., Berliana, D., & Yulia, M. (2022). Liquid organic fertilizer development strategy based coffee leather and raw materials to increase revenue local coffee robusta farmers. *IOP Conference Series: Earth and Environmental Science*, *1012*(1), 012047. https://doi.org/10.1088/1755-1315/1012/1/012047

Azhar, N., Kastaman, R., & Bunyamin, A. (2021). Penentuan produk agroindustri unggulan di Kabupaten Sumedang. *JEPA (Jurnal Ekonomi Pertanian Dan Agribisnis)*, *5*(3), 840–851. https://doi.org/10.21776/ub.jepa.2021.005.03.21

Eriyatno. (2012). *System Science Volume 1: Improving Quality and Effectiveness Management*. Guna Widya.

Fadhil, R., Maarif, M. S., Bantacut, T., & Hermawan, A. (2018). Formulation for development strategy of gayo coffee agroindustry institution using interpretive structural modeling (ism). *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *66*(2), 487–495. https://doi.org/10.11118/actaun201866020487

Hariance, R., Febriamansyah, R., & Tanjung, F. (2015). Agribisnis perkebunan rakyat kopi robusta di Kabupaten Solok. *Jurnal AGRISEP*, *14*(1), 11–25. https://doi.org/10.31186/jagrisep.14.1.11-25

Jaya, R., Machfud, & Islam, M. (2011). Aplikasi teknik ism dan me-mcdm untuk identifikasi posisi pemangku kepentingan dan alternatif kegiatan untuk perbaikan mutu kopi gayo. *Jurnal Teknologi Industri Pertanian*, *21*(1), 1–8.

Lamefa, D. Y., Sukardi, & Raharja, S. (2020). Strategi pengembangan agroindustri kopi di Kabupaten Kerinci. *Jurnal Agro Industri Perkebunan*, *8*(2), 85–98. https://doi.org/10.25181/jaip.v8i2.1480

Marimin. (2017). *Sistem Pendukung Pengambilan Keputusan dan Sistem Pakar*. IPB Press.

Murthy, P. S., & Madhava Naidu, M. (2012). Sustainable management of coffee industry by-products and value addition—A review. *Resources, Conservation and Recycling*, *66*, 45–58. https://doi.org/10.1016/j.resconrec.2012.06.005

Narulita, S., Winandi, R., & Jahroh, S. (2014). Analisis daya saing dan strategi pengembangan agribisnis kopi Indonesia. *Jurnal Agribisnis Indonesia*, *2*(1), 63–74. https://doi.org/10.29244/jai.2014.2.1.63-74

Novita, E., Fathurrohman, A., & Pradana, H. A. (2019). Pemanfaatan kompos blok limbah kulit kopi sebagai media tanam. *AGROTEK: Jurnal Ilmiah Ilmu Pertanian*, *2*(2), 61–72. https://doi.org/10.33096/agrotek.v2i2.62

Novita, E., Suryaningrat, I. B., Andriyani, I., & Widyotomo, S. (2012). Analisis keberlanjutan kawasan usaha perkebunan kopi (kupk) rakyat di Desa Sidomulyo Kabupaten Jember. *Agritech*, *32*(2), 126–135.

Oka, W. S. G. A., Apriyani, B. L., & Candra, K. D. K. A. (2021). Analisis kelayakan pada agroindustri kopi bubuk di Desa Nogosari Kecamatan Rambipuji Kabupaten Jember. *JEPA (Jurnal Ekonomi Pertanian Dan Agribisnis)*, *5*(2), 414–432. https://doi.org/10.21776/ub.jepa.2021.005.02.12

Putri, A., Yusmani, Y., Paloma, C., & Zakir, Z. (2018). Performance of production factors of arabica coffee (Coffea arabica L) in Lembah Gumanti, Solok Regency, West Sumatera. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, *7*(3), 189–197. https://doi.org/10.21776/ub.industria.2018.007.03.7

Rochmah, H. F., Kresnanda, A. S., & Asyidiq, M. L. (2021). Pemanfaatan limbah ampas kopi sebagai upaya pemberdayaan petani kopi di CV Frinsa Agrolestari, Bandung, Jawa Barat. *Jurnal Sains Terapan*, *11*(2), 60–69. https://doi.org/10.29244/jstsv.11.2.60-69

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, *1*(1), 83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Sargent, R. G. (2013). Verification and validation of simulation models. *Journal of Simulation*, *7*(1), 12–24. https://doi.org/10.1057/jos.2012.20

Saxena, J. P., Sushil, & Vrat, P. (1992). Hierarchy and classification of program plan elements using interpretive structural modeling: A case study of energy conservation in the Indian cement industry. *Systems Practice*, *5*(6), 651–670. https://doi.org/10.1007/BF01083616

Simatupang, A. E. C., Simatupang, J. T., & Berutu, P. T. S. S. (2022). Analisis nilai tambah dan strategi pengembangan agroindustri kopi bubuk robusta. *Methodagro: Jurnal Penelitian Ilmu Pertanian*, *8*(1), 67–76.

Sobana, D. H. (2018). *Studi Kelayakan Bisnis*. CV Pustaka Setia.

Wibowo, Y., Ma'arif, M. S., Fauzi, A. M., & Adrianto, L. (2011). Strategi pengembangan klaster industri rumput laut yang berkelanjutan. *Agritek*, *12*(1), 85–98.

Widaningsih, R. (2020). *Buku Outlook Komoditas Perkebunan Kopi*. : Pusat Data dan Sistem Informasi Pertanian Sekretaris Jenderal - Kementerian Pertanian.

Widyotomo, S. (2013). Potensi dan teknologi diversifikasi limbah kopimenjadi produk bermutu dan bernilai tambah. *Review Penelitian Kopi Dan Kakao*, *1*(1), 63–80.

Zulueta, Y., Martell, V., Martínez, J., & Martínez, L. (2013). A Dynamic Multi-Expert Multi-Criteria Decision Making Model for Risk Analysis. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 8265 LNAI* (Issue PART 1, pp. 132–143). https://doi.org/10.1007/978-3-642-45114-0_11

Designing Model for the Development of Sustainable Small Coffee Agroindustry at the Agropolitan Area of Ijen, East Java, Indonesia

ORIGINALITY REPORT

5%	4%	2%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universitas Jember Student Paper	2%
2	industria.ub.ac.id Internet Source	1%
3	repository.unmuhjember.ac.id Internet Source	1%
4	repository.unej.ac.id Internet Source	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		