Sustainable Arabica coffee development strategies in Aceh, Indonesia

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Abstract. Arabica coffee is Aceh’s leading commodity, apart from being an export product, it also plays an important role in the income of coffee farmers. Besides known as specialty coffee, Arabica coffee of Aceh has received international acknowledgment through several certifications, such as Fair Trade, Organic, or both, and other certificates. This study was conducted to develop sustainable development strategies for Arabica coffee of Aceh in the two largest coffee-producing districts, namely Bener Meriah and Aceh Tengah. Field study had been conducted from 1 December 2019 to 15 March 2020. Data were analysed by following the basic structure of the strengths, weaknesses, opportunities, and threats (SWOT) analysis. Sustainable arabica coffee can be carried out through implementing, monitoring, and evaluating policies related to coffee sustainability, increasing coffee productivity through climate-smart coffee practices, such as shade of coffee plantation, soil and water conservation, pest and disease control, development of new clones adapting to climate change, maintaining consistency of farmer’s coffee quality, increasing coffee production by social forestry patterns mainly for coffee farmers who are currently in protected areas, and encouraging millennials to enter the coffee business (particularly in the upstream area).

1. Introduction

Coffee is a C-3 woody species and one of the most important global crops that provides a livelihood to millions of people living in developing countries. Coffee is a highly popular beverage that is consumed by about one-third of the world’s population. As a particular tropical crop, coffee is cultivated in more than 80 countries, and supports the livelihoods of about 25 million small farmers [1], and become the main economic support for these countries. Most of the world coffee trade is supported by only two species, Coffea arabica L. (Arabica coffee) and Coffea canephora Pierre ex A. Froehner (Robusta coffee), which together account for approximately 99% of coffee beans produced [2,3]. The annual world production is above 8 million tons of coffee beans and generates income close to U.S. $ million for the entire coffee value chain [4].

The coffee plantation area in Indonesia reached more than 1.24 million ha, whereas 933,000 ha are robusta plantations and 307,000 ha are arabica plantations. Aceh is the largest producer of Arabica coffee in Indonesia, the production reached 59.489 tons within the area of 100.590 ha in 2018 [5].
Arabica coffee in Aceh is cultivated in the region of Gayo Highlands including Bener Meriah district, Aceh Tengah district, and Gayo Lues district. The area of a coffee plantation in the three districts increased from 39,490 ha, 46,540 ha, and 2,474 ha in 2006 to 46,294 ha, 49,366 ha, and 4,930 ha in 2018.

Global coffee production and its sustainability are potentially threatened by the present and ongoing climate change [6] because coffee is highly sensitive to climate change [7]. Modeling studies based on projections of rising temperatures and altered precipitation patterns have predicted remarkable effects on the coffee crop including changes in suitable areas for coffee cultivation, i.e. up to 50% growth by 2020s from areas traditionally cultivate C. arabica [8,9], increased pest and disease pressure [10], these changes would reduce climatic suitability for Arabica coffee at low elevations and higher areas [12]. This condition will impact to a change in plant transition to new areas [8,10], decreases in coffee yields (12,8,11), and negative impacts on biodiversity and wild populations of C. arabica [3]. Overall, these factors can cause a serious impact on environmental, economic, and social problems, especially in areas where coffee is currently grown [13]. Adaptation and mitigation strategies must be implemented to increase the sustainability of coffee species in the context of climate change.

On the other hand, when companies realize that the social and environmental situations in which they buy coffee are key factors for determining business performance, they start to make sustainability a part of their business operations [15]. Coffee sustainability has evolved from a movement led by civil society to become a core business of coffee trading companies and roasters. It attracts substantial investment from both individual companies and the coffee industry, acting collaboratively. Some certificates and verification schemes of global coffee production have emerged as much as 40 % in 2013 [15].

The above condition indicates that there are three major obstacles in limiting the reach of coffee sustainability. First, when more organized producers adopt it, transitioning half of current coffee production outside of the sustainability will require new commitments and investments. Second, coffee demand is projected to increase 150 percent by 2050 and, at current productivity levels, 200,000 km² of land will need to be cleared to prepare the coffee fields. Third, the fact that climate change is disrupting coffee production, making the lowlands less suitable and the highlands more suitable for growing areas, making the threat to the remaining forest even greater [10, 16]. The premise for creating sustainable coffee is although coffee has organizations to deal with public sector governance (e.g. the International Coffee Organization, producer organizations, technical services) and dialogue (e.g. the Global Coffee Platform), there is a need to further strengthen demand and promote transparency [17]. Conservation International plans to create an online and open-source portal for industry members to publicly announce and report their commitment to sustainability [16]. The conditions indicate the need to develop a strategy for sustainable coffee development in Aceh, especially in addressing these three main challenges.

2. Methods
2.1 Data
This study was designed by grouping the research area into two districts, Bener Meriah and Aceh Tengah. The data collection technique used a purposive random sampling method. The data sources of this research are primary and secondary. Primary data is data generated through direct searches by researchers to the field through survey methods in in-depth interviews and interviews, and Focus Group Discussions (FGD). Primary data collection includes three Sub-districts in Bener Meriah and 3 Sub-districts in Aceh Tengah, each of which represents an altitude of 1000-1200 m asl, 1200-1400 m asl, and 1400-1600 m asl which involved 225 farmers. Besides, in-depth interviews were also carried out with sources who were deemed to have sufficient knowledge and information on the research topic. FGDs were held in Bener Meriah and Aceh Tengah districts, involving the government/ policymakers (Head of Bappeda, Head of Agriculture and Plantation Service, Head of Industry and Trade Service, Head of Cooperative Service, Research Institute), academics, community leaders, Gayo Coffee Protection Community, Gayo Cupper Team, collectors, cooperatives and exporters/ coffee companies and non-governmental organizations.
Secondary data used in this study are data between 2006 and 2018, based on existing data obtained through public libraries, government agencies, print, and electronic media, author personal collections, and internet sites. The data that have been obtained, are then collected and compared to get generalizations about the data.

2.2. Data Analysis
Data analysis was carried out by following the basic structure of the SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats), we describe the strengths with a focus on sustainability coffee, looking at the weaknesses of the current condition, examining several examples and whether can reach the existing opportunities, as well as some of the risks/ threats that may occur. This SWOT analysis is structured as a 2x2 grid matrix that focuses on two internal dimensions (strengths and weaknesses) and two external dimensions (opportunities and threats). In principle, SWOT analysis can be used in any decision-making situation when the desired final condition, i.e. the goal, has been set. Combining the SWOT approach with fact-finding and in-depth validation of current literature and scientific reports, this study seeks to assess the overall impact, while developing strategies (conclusions) as recommendations for policy-makers.

3. Results and discussion
3.1. Results
The results of interviews and FGDs conducted with stakeholders in Bener Meriah and Central Aceh districts resulted in several conclusions regarding the strengths, weaknesses, opportunities, and threats of the sustainability of arabica coffee in Aceh. The summary of strengths, weaknesses, opportunities, and threats is:

| Table 1. Results of SWOT analysis of strengths, weaknesses, opportunities, and threats related to the sustainability of Aceh arabica coffee. |
|---|---|
| 1. **Strengths** | Aceh arabica coffee, as a specialty coffee has a taste that is well known in international and national markets. Arabica coffee of Aceh is generally managed organically and meets “ethical” (Fair-trade) principles. Aceh Arabica coffee has had a geographic indication (IG) since 2010. Aceh Arabica coffee is grown on a large expanse of upland. Aceh Arabica coffee already has superior varieties that are recognized nationally. The experience of farmers in managing coffee gardens is quite good. Relatively low production costs. |
| 2. **Weaknesses** | The relationship between organic cooperatives and their members is less harmonious. IG has not been used as a standard by the international market. Low coffee productivity, and inconsistent taste quality. The cooperative lack capital to buy coffee from members. Land for the development of new coffee is increasingly limited. Water sources are decreasing. |
| 3. **Opportunities** | The demand for Aceh Arabica coffee is quite high, both nationally and internationally. Aceh arabica coffee prices are relatively high. The existence of an agroforestry development program through a social forestry pattern. Company CSR that can be used for coffee training. |
| 4. **Threats** | Climate change, and increasingly stringent coffee quality requirements set by importing countries. There was a refusal from buyers of Aceh arabica coffee. The application of the principle of sustainable coffee has not been carried out well. The development of specialty and organic coffee from other regions and countries. |

Based on the conditions of strengths, weaknesses, opportunities, and threats, the strategies developed are:
Table 2. The result of the strategy analysis using strength to get opportunities.

| Strengths (+) / Opportunities (+) |
|-----------------------------------|
| 1. Maintaining the image of specialty coffee from Aceh Arabica coffee with famous flavors that are managed with organic and fairtrade principles to meet the demands of national and international markets at fixed prices. |
| 2. Increasing superiority in existing aspects of cultivation by utilizing the company's CSR to improve the competence of coffee farmers. |

Table 3. The results of strategic analysis to correct weaknesses to gain opportunities.

| Weaknesses (-) / Opportunities (+) |
|------------------------------------|
| 1. Maintaining better organic cooperative management and a fair trade system, that there is better trust between the cooperative and its members, and the demand for higher-priced coffee can be maintained. |
| 2. Applying an existing GI certificate to keep the copy image trusted. |
| 3. Increasing productivity while maintaining consistency of taste, being able to meet market demands both nationally and internationally. |
| 4. Maintaining the existing ecosystem by developing agroforestry patterns in social forestry, especially on farmers' land in protected areas. |

Table 4. The results of strategy analysis using strength in managing threats.

| Strengths (+) / Threats (+) |
|-----------------------------|
| 1. Utilizing the good experience of farmers and organic cultivation patterns to apply the "Climate Smart Coffee Practices" cultivation pattern. |
| 2. With low production costs, as well as improved specialty coffee management systems. organic and fair trade patterns and the advantages of existing cultivation technologies will produce coffee that can compete from other regions and countries. |

Table 5. The results of the analysis of strategies to fix weaknesses to overcome threats.

| Weaknesses (+) / Threats (+) |
|-----------------------------|
| 1. Maintaining existing regulations, especially in forest area management, applying the principle of sustainable coffee, and implementing a coffee intensification system through “Climate Smart Coffee Practices” will be able to increase farmer’s adaptation to climate change. |
| 2. Improving better governance of organic coffee and fair trade will increase the trust between the cooperative and its members, that coffee produced by farmers is not contaminated with prohibited substances and does not receive a rejection from buyers. |

3.2. Discussion

From the overall strategy, either using the approach of using strength to get a better chance [Strength (+) / Opportunity (+)], or fixing the weakness to get a chance [Weakness (-) / Opportunity (+)], using strength to overcoming threats [Strength (+) / Threat (+)], and improving existing weaknesses to overcome threats [Weakness (+) / Threat (+)], several activities that need to be implemented immediately to achieve sustainability in Aceh arabica coffee are:

3.2.1. Implementing, monitoring, and evaluating policies related to sustainability coffee. Distinctive arabica coffee has received more attention for certain market segments, which should be useful to coffee production centers particularly in the highlands of Aceh. Additionally, developing unique quality and niche markets using a combination of diversity, location, and processing technology. These advantages are combined with 1) the varieties grown by our farmers produce the highest quality coffee, 2) climate and soil types in the region strongly support the production of delicious and distinctive coffee, 3) The unique wet stripping method creates the best coffee taste, and 4) cultivation is generally carried out following consumer demand, namely farming with an organic farming system and fulfilling fair trade ethics. However, for its sustainability, it needs to be done through continuous monitoring and evaluation.
of policies, which include: protecting forest areas, improving cooperative governance for better organic certification, fair trade, and others, encouraging the use of GI for every coffee product exported, while at the same time encouraging the operation of Organic Fertilizer Manufacturing (IPPO) to support organic coffee cultivation.

Increase coffee productivity through intensification and application of adaptive coffee cultivation to climate change (climate-smart coffee practice). Several strategies for increasing coffee productivity are related to adaptation to climate change, one of which is handling coffee shade. The agroforestry pattern is a very potential pattern for the implementation of climate change mitigation and adaptation. A multi strata agroforestry system needs to be applied to manage variability in seasonal rainfall and temperature extremes. In Nicaragua, the concept of adaptation has been developed [18,19] to provide specific recommendations for coffee growing areas to adapt to time and space. They identified four main impact scenarios in 2050 for coffee according to the altitude of the growth zone and adaptation strategies, namely 1) at low altitude (500-800 m asl), arabica coffee will disappear and adaptation transformations are recommended (e.g. replacing arabica coffee with robusta coffee or cacao); 2) medium altitude (800-1200 m asl), where projections of large negative changes and additional adaptations are recommended (e.g. new and diversified varieties); 3) high altitude (1200-1,400 m asl), where slight negative changes are projected and additional adjustments are recommended (e.g. shading and irrigation); and 4) very high altitudes (1400–1600 m asl), where positive changes are projected and transformational adaptations are recommended (e.g. expansion into new areas) [9].

The next strategy is to conserve soil and water. Soil management plays a very important role in coffee agroforestry cultivation, which includes the provision of sufficient organic matter in the soil and the utilization of microbes such as mycorrhizal fungi. Also, considering that arabica coffee cultivation areas are generally located in upland areas with hilly to mountainous topography, erosion control by preserving soil and water is needed. The results of the research by Basri et al. [20] in several villages in Bener Meriah, it is seen that the level of erosion hazard (TBE) on the slopes of 30% is classified as very severe, while TBE on the slopes of 8 percent is classified as mild.

Furthermore, another strategy to increase coffee productivity is integrated pest and disease management. The main problem of climate change in coffee cultivation is the increasing attack of coffee pests. Pest control of coffee plants in an organic farming pattern can be carried out using an integrated pest and disease control system, that prioritizes biological control. The fungus Beauveria bassiana can be used to control Trichoderma sp, coffee powder pests, for the control of coffee root fungus. Besides, neem leaf extract (Azadirachta indica) can be used as a biological pesticide. Proper pathogen control and pest infestation, coupled with adequate fertilization and irrigation (and associated agronomic practices, such as introducing organic matter into soils and terracing, and mulching high slopes), can significantly reduce negative impacts on coffee cultivation [21].

The development of new clones that can adapt to climate change is the next step to address the problem of declining coffee productivity. Currently, in the Gayo Highlands there are two recommended clones, Gayo-1 and Gayo-2, meanwhile in the recommendation process is the Ateng Super clone (a variety that is favored by farmers, besides having high yields, it is also well adapted to almost all areas of development, and are more resistant to pests and diseases). But with changing climatic conditions, Aceh must prepare several scenarios for varieties that can adapt well to warmer temperatures, are more resistant to pests and diseases, and have a good taste. Apart from developing new clones [9], it can also be done by developing a vegetative culture of arabica coffee on the robusta variety. Grafting arabica stems to robusta rootstocks can be a good and fast alternative to the relatively slow breeding process, to increase tolerance to environmental stresses such as drought [22]. Grafting from arabica to robusta has been used elsewhere in Indonesia as a means of dealing with attacks to roots by various fungi and nematodes [23].

3.2.2. Maintain consistency of farmer’s coffee quality. Apart from coffee productivity, the most prominent problem in coffee production related to coffee sustainability is the consistency of quality. Quality and production issues must be handled adequately. This affects socio-economic factors
including the welfare of the community, especially the welfare of coffee farmers. Coffee is a unique and very complex commodity, whose quality is influenced by many factors from the cultivation stage to the coffee cup. These factors can be caused by geography, climate, altitude and temperature, shade, and nutrients or fertilizers. [24] reported that shading led to the slower and more balanced filling of the beans, and uniform ripening of the fruit, resulting in better product quality than shaded coffee plants. Increase the capacity of farmers in 'Good Handling Practice' (GHP) through training and mentoring, develop standard operational guidelines on a good harvest and post-harvest handling, and support the provision of post-harvest support equipment (such as pulper, huller quality, and diesel/bed dryer) for both individual and communal is an option that can be explored further.

3.2.3. Increase coffee production through social forestry schemes, especially for coffee farmers who are currently in protected areas. When the impacts of climate change occur, increased coffee production can lead to significant deforestation because many areas suitable for coffee cultivation in 2050 are mostly in natural forest ecosystems. The greatest risk of future deforestation is due to expansion or shifting of coffee growth [17]. Climate change will disrupt the sustainability of coffee production, make the lowlands less suitable, and the highlands more suitable, and the threat to intact forests will be even greater [10]. The increasing demand for Arabica coffee is likely to drive forest conversion. Forest loss will negatively impact and increase threats to vertebrate species and priority conservation areas, and result in carbon emissions [10]. Deforestation, climate change, and water shortages cannot be reversed by agriculture or the coffee industry. In a landscape approach, different land users in an area need to create integrated action plans to address the causes of perceived environmental damage [25].

3.2.4. Encourage millennials to enter the coffee business (especially in upstream). The results of the study in the Gayo Highlands show that the coffee farmers in the upstream sector are elderly, and there are indications that the younger generation is no longer interested in coffee cultivation. The Center for Agricultural Data and Information Systems [26] reports that in general, in the agricultural sector, the number of female workers continues to increase, while middle productive age workers (35-54 years) are increasing slowly, and workers of young productive age (15-34 years) are decreasing, this indicates that the younger generation is less interested in agriculture. The government has issued a policy to mobilize the younger generation in the agricultural sector through the Decree of the Minister of Agriculture Number 07 / Permentan / OT.140 / I / 2013 concerning Guidelines for the Development of the Young Generation of Agriculture (workers aged 15-34 years age groups), need to get priority in determining the planning of agricultural development programs so that they can become the next generation, motivators, innovative pioneers, creative, professional, independent, competitive, and have a global perspective. One group of the younger generation is the Young Farmer Entrepreneurs, where the workers aged 20 to 35 years, who are independent agribusinesses and consider agriculture as their livelihood and have an entrepreneurial spirit.

The study by Sumiarti et al., [26] in the coffee sector in Simalungun shows that there is equality in access and control exercised by young coffee farmers and their parents. The gap arises because there are some young women coffee farmers and women who do not have control or benefit over resources. [27] offers a relevant strategy, by changing the perspective of the young generation on the stigma of underdeveloped agriculture through the formation of the character of the younger generation as well as policy incentives and facilities for developing superior commodity-based agribusiness and agroforestry-industries. It will be achieved through training, education, or mentoring to potential young farmers.

4. Conclusions
The sustainability of the coffee sector in Bener Meriah and Aceh Tengah Regencies can be achieved through five strategies, including implementation, monitoring, and evaluation of policies related to coffee sustainability, increasing coffee productivity through intensification and application of adaptive coffee cultivation to climate change (climate-smart coffee practices), maintaining consistency of farmers
coffee quality, increasing coffee production through social forestry schemes, especially for coffee farmers who are currently in protected areas, and encouraging millennials to enter the coffee business.

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