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Strategy of Development of Sustainable Red Chili Agribusiness Areas in North Sumatra Province

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Abstract

The development of sustainable red chili agribusiness areas in North Sumatra Province is a challenge that involves various aspects, including cultivation technology, farmer institutions, supply chain efficiency, government policy support, and environmental sustainability. This study aims to identify and formulate a sustainable red chili agribusiness development strategy that can increase farmers' productivity and welfare without sacrificing the environment. Through a qualitative approach, data were collected from in-depth interviews with farmers, agribusiness stakeholders, as well as a review of government policies related to sustainable agriculture. The results show that the application of precision agriculture technology, such as drip irrigation systems and integrated pest management, can significantly increase productivity while preserving natural resources. Strengthening farmer institutions, such as cooperatives, is also very important in coordinating production, improving market access, and stabilizing farmers' income. In addition, supply chain efficiency through the construction of storage and distribution centers will reduce post-harvest losses and price fluctuations, while government policy support is needed in the provision of agricultural infrastructure and stable price regulation. In conclusion, the sustainable development model of red chili agribusiness areas must include synergies between environmentally friendly technologies, strong institutions, efficient supply chains, and proactive policy support. With this model, red chili agribusiness areas in North Sumatra can develop sustainably, contribute to food security, and improve farmers' welfare.

Keywords: *Red Chili Agribusiness, Regional Development, Sustainability, North Sumatra, Farmer Institution.*

Introduction

North Sumatra Province is one of the agricultural areas that has great potential in the development of the agribusiness sector (Martauli, 2021). Among the flagship commodities produced is red chili, which has become a major source of income for many farmers in the area. Red chili, in addition to being an important food, also has high economic value in the local and national markets (Riyadh, 2019). However, challenges in terms of production, distribution, and sustainability of red chili farming are still often obstacles in achieving maximum sustainable yields. Therefore, a more targeted and integrated agribusiness area development model is needed to ensure the sustainability of this sector.

A sustainable red chili agribusiness development model is important to be developed to answer the challenges faced by farmers and agribusiness industry players in North Sumatra. The need to increase productivity, efficiency, and expand market access is urgent in the development of the red chili agricultural sector. Currently, various factors such as climate change, land conversion, and market price fluctuations add complexity in the management of red chili farms (Arifin, 2021). Therefore, a comprehensive approach is needed to develop red chili agribusiness areas that are not only productive but also environmentally friendly.

The development of sustainable red chili agribusiness areas must pay attention to various aspects, including cultivation technology, resource management, and post-harvest management. By utilizing the right technology, farmers can increase their yields without damaging the environment. One of the technologies that has been widely applied in various regions is the use of drip irrigation and organic farming systems.

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This technology allows farmers to conserve water and reduce the use of chemicals that damage the soil (Nainggolan et al., 2023).

In addition, the role of the government in providing supporting facilities and regulations is also very crucial. The government can play a role in providing training to farmers on efficient and environmentally friendly cultivation techniques. In addition, the government must also ensure that agricultural infrastructure such as access roads to markets, storage warehouses, and transportation facilities are adequate to minimize post-harvest losses. Partnerships between farmers, the government, and the private sector are also important in realizing the sustainable development of agribusiness areas. Cooperation between these three parties can create a more efficient supply chain that benefits all parties. Farmers will get market certainty, while the private sector can secure the supply of quality raw materials, and the government can encourage local economic growth.

Basically, the success of the development of red chili agribusiness areas is highly dependent on the involvement of all parties, including universities and research institutions. Through research and innovation, universities can help overcome technical problems faced by farmers, such as pest attacks and diseases. With in-depth research, pest and disease control methods can be found without having to rely on pesticides that damage the environment. In addition, the sustainability aspect must also pay attention to the welfare of farmers. In many cases, despite increased production, farmers often still face the problem of unstable selling prices. Fluctuations in the price of red chili peppers are very high often making farmers lose money, especially when prices plummet during the harvest season. Therefore, it is important to create a stable and fair pricing mechanism for farmers (Pangestu, 2018).

North Sumatra is one of the provinces in Indonesia that makes agriculture have a strategic place in the economy of North Sumatra (Novita et al., 2023). The agricultural sector is a mainstay sector as a contributor to GDP and also as the sector that absorbs the most labor compared to other sectors. Based on BPS data, the agricultural sector is still the highest sector in contributing to GDP in North Sumatra despite the decline. The Agriculture sector contributed 20%-22% over the last 5 years.

Table 1. Distribution of PRDB on the Basis of Applicable Prices According to Business Fields in North Sumatra Province in 2015-2019

Less	Business Field	Year				
		2015	2016	2017	2018*	2019**
1	Agriculture	21,95	21,55	21,38	20,91	20,48
2	Mining	1,34	1,35	1,30	1,29	1,27
3	Processing Industry	20,24	20,05	20,28	20,01	18,98
4	Electricity Procurement	0,11	0,11	0,12	0,11	0,11
5	Procurement of water, garbage,	0,10	0,10	0,11	0,10	0,10
6	etc.	13,61	13,45	13,66	13,88	14,19
7	Construction	17,46	17,84	17,54	18,11	18,95
8	Wholesale and retail trading	4,99	5,08	5,02	4,99	5,06
9	Transportation and warehousing	2,41	2,39	2,37	2,38	2,42
10	Provision of accommodation	1,95	1,95	2,01	2,04	2,14
11	Information and Communication	3,34	3,31	3,17	3,05	2,91
12	Financial and insurance services	4,50	4,75	4,97	5,03	5,11
13	Real Estate	0,95	1,00	1,03	1,03	1,08
14	Corporate Services	3,71	3,67	3,71	3,68	3,74
15	Government Administration	1,88	1,88	1,82	1,82	1,84
16	Educational Services	0,93	0,95	0,96	0,98	1,02
17	Healthcare Services	0,53	0,56	0,58	0,57	0,59
	Other Services					

Source: North Sumatra in 2020 Figures

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Meanwhile, in terms of labor absorption, the agricultural sector absorbed as many as 2,374,440 people or 35.54% of the total of 6,681,224 people in 2019. Then, followed by the processing industry sector.

One of the subsectors in agriculture that has the potential to be developed is horticulture. Horticultural commodities are still commodities that are a priority and concern. One of the policies of the Ministry of Agriculture is the Development of Horticultural Agribusiness Areas (PKAH) where the development of horticultural commodities is directed at the development of vertically and/or horizontally integrated areas by consolidating highly competitive productive businesses (Wahyudi, 2020). Integrated development means that the welfare of all levels of society must be improved and equitable. (Directorate General of Horticulture, 2018). Based on Law Number 13 of 2010, it is stated that a horticultural area is an expanse of horticultural commodity business that is united by certain binding factors, be it natural, socio-cultural or other infrastructure factors (Imanullah, 2017).

However, horticultural commodities in North Sumatra Province experienced the lowest growth rate compared to other subsectors, Based on BPS data, the average growth rate of the horticultural subsector was 1.54% per year. This is a decrease in value in 2019 by -0.37% compared to 2019. This condition shows that there are problems that occur in the horticultural subsector in North Sumatra.

Table 2. Growth Rate of Agricultural Subsector in 2015-2019 (%)

Subsectors	2015	2016	2017	2018	2019	Flattening
1. Food Crops	9,46	7,57	4,48	2,15	4,10	5,55
2. Horticultural Crops	0,17	2,03	5,69	0,16	-0,37	1,54
3. Plantation Crops	5,61	4,47	5,52	6,59	7,47	5,93
4. Farm	6,63	6,78	6,64	6,78	6,28	6,62
5. Agricultural Services	2,79	1,98	5,02	-0,45	4,37	2,74
6. Forestry	3,89	-3,54	0,27	6,86	2,64	2,02
7. Fishing	5,66	5,74	5,87	2,15	-2,15	3,45
Agriculture Sector	5,57	4,65	5,31	4,87	5,13	5,11
North Sumatra GDP	5,10	5,18	5,12	5,18	5,22	5,16

Source: BPS (processed)

One of the horticultural commodities that is targeted in the development of agricultural areas is Red Chili. Red chili is one of the leading commodities in horticulture and high value commodities and is in demand by the market, as stated in the Regulation of the Minister of Agriculture Number 131 of 2014, chili is one of the 7 (seven) national strategic food commodities, namely; rice, corn, soybeans, beef, sugar, chili and shallots which are developed in the mainstay areas as a whole (Lubis, 2021).
The need for chili peppers in Indonesia continues to increase along with the increase in the number of Indonesians. The average growth of Indonesian consumption was 28.91% in the period 2014-2018 or 5.70% in the period 1981-2018. This shows that the per capita consumption rate will continue to increase every year. The development of Red Chili consumption in Indonesia per capita per year is increasing in the period 2011 – 2018.

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Figure 1. Red Chili Consumption in Indonesia

Source : Outlook for Red Chili in 2019

The increase in Red Chili consumption has its own challenge, namely prices that tend to increase and fluctuate every year. Based on BPS data, the development of red chili prices at the producer and consumer levels during the period 1983 – 2018 shows an increasing trend. In the last 5 years, prices at the producer level have experienced an average growth of 12.68% per year. Meanwhile, the average price growth at the consumer level also grew by 13.73% per year (Red Chili Outlook 2019). The development of producer and consumer prices in Indonesia for the period 1990 – 2018 can be shown in figure 2 below.

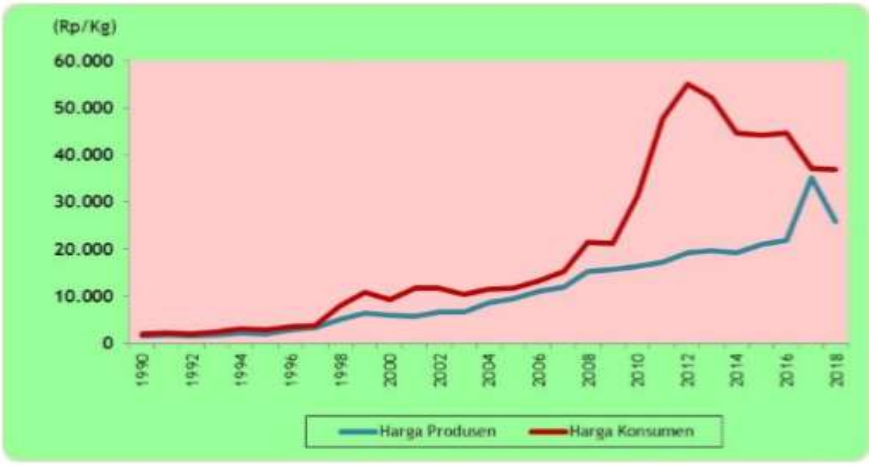

Figure 2. Producer and Consumer Price Development in Indonesia for the Period 1990-2018

North Sumatra Province is the third largest Red Chili production center in Indonesia. Based on the average production in 2014-2018, West Java contributed 23.03% to the total production of large chili peppers in Indonesia, Central Java 15.57%, North Sumatra 114.40%, East Java 8.80%, West Sumatra 7.04% and Aceh 4.84%.

Table 3. Red Chili Production by Province in Indonesia

Province	Red Chili Production (Tons)					Flattening	Share (%)
	2014	2015	2016	2017	2018		

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West Java	253.296	240.864	242.113	274.311	274.037	256.924	23,03
Central Java	167.794	168.411	164.980	195.571	171.796	173.710	15,57
North Sumatra	247.810	187.833	152.630	159.131	155.835	160.648	14,40
East Java	111.022	91.135	95.539	100.977	91.965	98.128	8,80
West Sumatra	59.390	63.402	68.224	95.489	106.061	78.513	7,04
Aceh	50.189	52.906	45.449	53.041	68.151	53.947	4,84
Other	285.100	240.632	276.652	327.746	338.892	293.804	26,33
English	1.074.602	1.045.182	1.045.587	1.206.266	1.206.737	1.115.675	100

Source : Outlook for Red Chili in 2019

In the last 3 years (2018-2020), it can be seen that the monthly price fluctuations of red chili in North Sumatra fluctuate greatly. This condition shows that there are problems in managing *the supply* and *demand* of Red Chili commodities in North Sumatra. During this period, the price of red chili was at the highest price of around Rp 67,000 per kilo and the lowest at Rp 17,000 per kilo (PIHPS, 2020). The existence of this fairly high gap is a special concern so that efforts are needed to reduce price spikes that are too high.

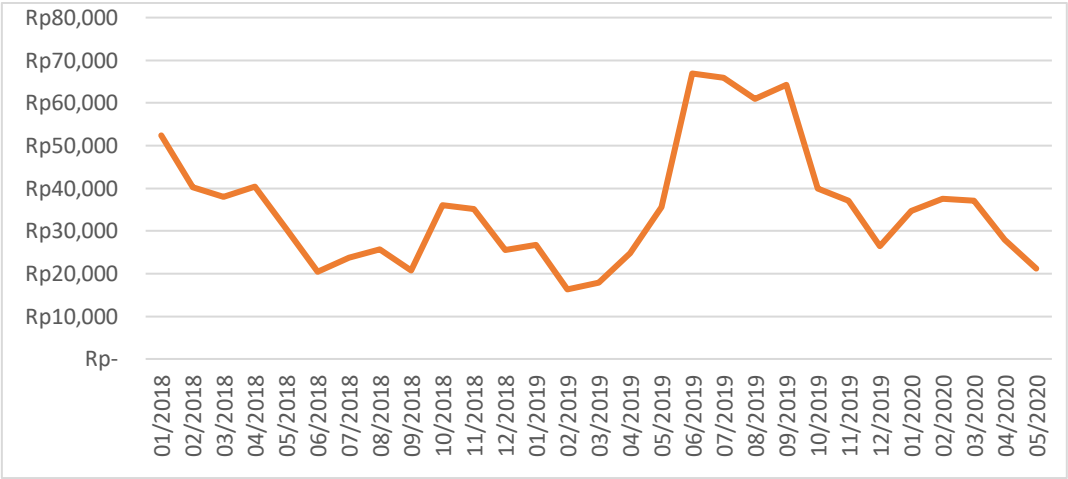

Figure 3. Red Chili Price Development January 2018 – May 2020

Source: www. https://hargapangan.id/

Although North Sumatra is the third largest production center in Indonesia, commodities are still one of the main contributors to inflation and have the largest weight in shaping inflation in North Sumatra. According to Rahmanta (2020), the price of red chili one month earlier and the price of red chili have a positive effect on the formation of inflation in Medan City both in the short, medium and long term. Inflationary pressures in North Sumatra are triggered by an increase in the price of red chili commodities (Bank Indonesia, 2020). The same thing was also stated by Adebusuyi 2004; Udoh and Sunday 2007; Kustiari, R et al (2018) that commodity prices, especially red chili prices, are able to cause food price volatility and inflation.

In addition to the problem of price fluctuations, there are other problems in the red chili commodity. The existence of a fairly high price disparity between prices at the consumer level and prices at the producer level indirectly indicates that the position of farmers is still weak. In terms of farmers' welfare as shown by the Farmer Exchange Rate (NTP), it can be seen that the NTP in the horticulture subsector is still below other subsectors and also below the general average in North Sumatra Province. NTP below 100 indicates that farmers in North Sumatra are in the category of not yet prosperous due to the low purchasing power of farmers. The details of the NTP in North Sumatra Province are as follows:

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Table 4. Development of NTP in North Sumatra Province

Subsectors	2018	2019
Food Crops	96,58	91,74
Horticultural Crops	91,22	91,74
People's Plantation Crops	91,23	99,20
Farm	113,62	114,80
Fishing	103,79	103,63
Combined	**97,31**	**99,08**

Source: Central Statistics Agency (2020)

Thus, the development of sustainable red chili agribusiness areas in North Sumatra must be based on the principles of integration between production, processing, and marketing. Collaboration between various parties, the use of technology, and the improvement of institutional systems are the keys to achieving sustainability. From this, it becomes clear that the development of red chili agribusiness areas does not only focus on agricultural aspects, but also involves other related sectors. With a holistic approach, it is hoped that red chili from North Sumatra can become one of the leading commodities that is able to compete in the global market while providing sustainable welfare for farmers.

To illustrate the challenges and opportunities in the development of red chili agribusiness areas in North Sumatra Province, here is a table explaining the main factors that need to be considered:

Table 5. Key Factors to Look Out for

Aspects	Challenge	Chance
Cultivation Technology	Lack of application of modern technology	Adoption of drip and organic irrigation technology
Infrastructure	Limited road and transport access	Development of supporting infrastructure
Processing Results	Lack of chili processing facilities	Development of the processing industry
Price Fluctuations	Prices are unstable, especially during the big harvest	Strengthening farmer cooperatives and stabilizing prices
Milieu	The use of pesticides that damage ecosystems	Development of green agriculture
Institutional	Weaknesses in the farmer institutional system	Institutional strengthening through cooperatives
Financing	Difficulty in accessing capital for smallholders	Increased access to financial institutions
Market	Competition with imported products	Export potential to international markets

The table above explains that although there are various challenges in the development of red chili agribusiness areas in North Sumatra, there are also opportunities that can be used to achieve sustainability.

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Literature Review

The development of sustainable red chili agribusiness areas in North Sumatra Province requires a deep understanding of various concepts related to agribusiness, sustainability, agricultural technology, farmer institutions, as well as challenges and opportunities in the supply chain of agricultural products. In this literature review, some of the main literature and theories underlying this research will be discussed, to provide a strong academic foundation and explain the context of the development of red chili agribusiness as a whole.

Agribusiness

Agribusiness is generally defined as a sector that includes all activities related to the production, processing, distribution, and marketing of agricultural products (Davis & Goldberg, 1957). According to (Elizabeth, 2019), agribusiness involves not only farmers as the main actors, but also various other parties such as the government, processing companies, distributors, and consumers. In the context of red chili, agribusiness includes a whole series of activities from cultivation to marketing of red chili products, which must be managed efficiently in order to generate optimal economic benefits. Agribusiness development at the regional level involves an integrated systems approach. (Porter, 1998) in his theory regarding the Cluster Industry, he explained that the development of commodity-based areas must be carried out by strengthening synergy between various parties, ranging from farmers, input providers, processing industries, to local governments. This theory is relevant in the context of the development of red chili agribusiness areas, where the linkage between various actors is a key factor in creating efficiency and increasing product competitiveness.

Sustainability in Agriculture

The concept of sustainability in agriculture is becoming increasingly important in discussions regarding natural resource management, especially in the face of global challenges such as climate change and environmental degradation. According to (Efendi, 2016), sustainable agriculture is an agricultural system that can maintain long-term productivity, is environmentally friendly, and is able to provide sufficient income for farmers. In this case, sustainable red chili farming must pay attention to aspects of environmental sustainability, economic sustainability, and social welfare of farmers. (Schaller, 1993) emphasizing the importance of the triple bottom line in the concept of sustainability, which is paying attention to economic, environmental, and social aspects at the same time. The application of this concept in red chili agribusiness will include environmentally friendly cultivation technology, good management of water and soil resources, and a market approach that guarantees economic benefits for farmers. Study by (Sari et al., 2024) It also emphasizes that sustainable agriculture can increase productivity while maintaining the balance of the ecosystem if managed with the right technology.

Agricultural Technology

Technology plays an important role in increasing productivity and efficiency in agribusiness. According to (Gunawan et al., 2019), the adoption of technological innovations in agriculture is often determined by factors such as farmer knowledge, institutional support, and access to technological resources. Study by (Yuniati et al., 2024) It shows that drip irrigation technology, proper fertilization, and good post-harvest treatment can significantly improve the yield and quality of red peppers. Environmentally friendly cultivation technologies, such as organic farming, are also the focus of various studies related to agricultural sustainability. World Food and Agriculture Organization (Dongyu & Index, 1990) emphasizing the importance of technology that does not damage the soil and the environment in increasing food production, especially red chili which has a fast planting cycle. The adoption of this technology requires support from various parties, including technology providers, governments, and research institutions.

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Farmer Institutions

Strengthening farmer institutions is one of the keys to success in sustainable agribusiness development. According to (Uphoff, 1993), strong institutions can increase the capacity of farmers to access markets, resources, and information. Farmer institutions such as cooperatives or farmer groups play a role in facilitating collaboration between farmers, so that they can unite in facing market challenges and fluctuating prices. Study by (Supriadi & Sejati, 2018) It shows that strong farmer cooperatives can help red chili farmers in terms of cheaper procurement of agricultural inputs, access to a wider market, and protection from price fluctuations. This institution also plays a role in improving farmers' ability to manage finances and access to financing from formal financial institutions.

Agricultural Supply Chain

The supply chain of agricultural products, especially red chili, involves many actors from upstream to downstream. (Ashfaq & Raja, 2013) stated that an efficient supply chain can increase the added value of agricultural products through good management from production to distribution. In the context of red chili, an efficient supply chain includes proper logistics management, post-harvest management, and distribution systems that support marketing at both the local and national levels. In line with that, (Hertina et al., 2023) emphasizing the importance of integration between actors in the supply chain to reduce inefficiencies and improve product distribution. In red chili, problems such as post-harvest losses due to lack of storage facilities or inadequate transportation are often obstacles. The development of good logistics and storage infrastructure can be a solution to improve product durability and reduce losses.

Research Methods

This study uses a qualitative approach to dig deeper into the development model of sustainable red chili agribusiness areas in North Sumatra Province. The qualitative approach was chosen because this research aims to understand social, economic, and institutional phenomena in depth through direct interaction with agribusiness actors in the field. The qualitative method allows researchers to gain insight into the development process, challenges, and opportunities in the red chili agribusiness sector that are difficult to explain through quantitative numbers alone.

Research Approach

This study uses an exploratory descriptive approach to describe in depth the actual conditions of the development of red chili agribusiness in North Sumatra Province (Rukajat, 2018). This design was chosen to obtain information on how various aspects that affect agribusiness sustainability, such as technological factors, institutions, supply chains, and the role of governments, interact with each other. The exploratory approach also allows researchers to identify the patterns, views, and experiences of actors directly involved in the production and distribution process of red chili.

Location and Subject of Research

This research was conducted in North Sumatra Province, which is one of the red chili production centers in Indonesia. Several districts that have great potential in the development of red chili will be used as research locations, such as Karo, Simalungun, and Deli Serdang Regencies. This location was chosen based on the high production of red chili peppers and the existence of a large chili farming community.

The research subjects consist of various actors involved in red chili agribusiness, including:

Red chili farmers: As the main actors directly involved in the production process.

Cooperatives and farmer groups: Institutions that assist farmers in the management of agribusiness businesses.

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Local governments: Agriculture offices, trade offices, and other institutions related to agricultural policies and agribusiness development.

Market players: Traders, collectors, distributors, and processing industries that are part of the red chili supply chain.

Data Collection Techniques

Data collection in this qualitative research is carried out through several techniques, including (Jogiyanto Hartono, 2018):

In-Depth Interview: In-depth interviews are conducted with red chili farmers, cooperative members, and government representatives. This interview aims to explore their experiences, views, and understanding of the challenges and strategies in the development of red chili agribusiness areas. The interview will use a semi-structured guide to provide flexibility in exploring topics that arise spontaneously during the discussion.

Participatory Observation: Direct field observations will be conducted to understand the agribusiness practices of red chili firsthand, from the cultivation process to distribution. Researchers will participate in several agribusiness activities to gain a deeper understanding of the conditions and challenges faced by farmers.

Documentation: Secondary data collection from official documents such as government reports, regulations related to agribusiness, and reports from farmer cooperatives will be carried out. This data will help researchers understand the context of policies and regulations that affect the development of red chili agribusiness areas.

Data Analysis Techniques

Qualitative data analysis in this study is carried out through a process involving the following stages (Jogiyanto Hartono, 2018):

Data Reduction: Data collected from the results of interviews, observations, and documentation will be reduced or simplified by selecting information that is relevant to the focus of the research. This stage involves sorting the data based on important themes that emerge during the research, such as technological, institutional, market, and environmental factors.

Coding: After reduction, the data will be encoded to identify key patterns and themes. This coding is done by classifying each data according to a predefined category, but remaining open to new themes that may emerge during the analysis process.

Data Interpretation: Once the data is coded, the next step is to conduct an in-depth interpretation to relate the research findings to the theoretical framework used. This interpretation will provide insight into how the factors that affect the sustainability of red chili agribusiness interact with each other and affect each other.

Data Triangulation: To ensure the validity of the data, triangulation is carried out by comparing the results of interviews, observations, and documentation. This triangulation aims to ensure that the data obtained is consistent and reliable. In addition, triangulation was also carried out by confirming the research findings to the respondents.

Validity and Reliability

To maintain the validity and reliability of this study, several steps will be taken:

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Triangulation of data sources: Using a variety of data sources (interviews, observations, and documentation) to reduce bias and ensure the accuracy of information.

Member Checking: After the results of the analysis are conducted, the researcher will return the key findings to the respondents to ensure that the researcher's interpretation is in accordance with their understanding.

Audit Trail: The researcher will document every step in the research process, including data collection and analysis methods, so that the research process can be audited by other parties if necessary.

Research Results and Discussion

Based on location and natural conditions, North Sumatra is divided into 3 (three) groups of regions/regions, namely the East Coast, West Coast, and Highlands.

Table 6. Regency/City Regional Group in North Sumatra Province

East Coast	West Coast	Plateau
1. Labuhanbatu	1. Nias	1. North Tapanuli
2. North Labuhanbatu	2. North Nias	2. Toba Samosir
3. South Labuhanbatu	3. West Nias	3. Simalungun
4. Asahan	4. Mandailing Christmas	4. Dairi
5. Brick	5. South Tapanuli	5. Karo
6. Deli Serdang	6. Padang Lawas	6. Humbang Hasutututan
7. Langkat	7. North Padang Lawas	7. West Pakpak
8. Serdang Bedagai	8. Central Tapanuli	8. Samosir
9. Tanjungbalai	9. South Nias	9. Pematang Siantar
10. High Cliff	10. Padangsidempuan	
11. Terrain	11. Sibolga	
12. Binjai	12. Gunungsitoli	

Source : Sumatra in 2023 Figures

North Sumatra Province is classified as a tropical climate area influenced by Passat winds and Monsoon winds. The altitude of the land surface of North Sumatra Province is very varied, some areas are flat, only a few meters above sea level, the climate is quite hot, some areas are hilly with a gentle slope, the climate is moderate and some are at high altitudes. Like other provinces in Indonesia, North Sumatra Province has a dry season and a rainy season, the dry season usually occurs from January to July and the rainy season usually occurs from August to December, between the two seasons there is a pancaroba season. Average air humidity 78% - 91%, rainfall 800-4000 mm/year and solar irradiation 43%.

The development of sustainable red chili agribusiness areas in North Sumatra Province has a very strategic relevance in an effort to increase productivity and food security while making a significant economic contribution to the region. North Sumatra is known as one of the centers of national horticultural production, with red chili as one of the main commodities. In this context, the sustainable development model of red chili agribusiness areas must consider aspects of technology, institutions, markets, the environment, and the role of government policies.

Aspects of Technology and Sustainable Cultivation

Agricultural technology applied in the red chili agribusiness area in North Sumatra is a key factor in maintaining production sustainability. The technology used includes cultivation technology, water management, fertilizer use, and environmentally friendly pest management. Previous research by (Sari et al., 2024) emphasizing that the application of drip irrigation technology, the use of organic fertilizers, and an integrated pest management system can increase the yield of red peppers without damaging the environment. In this study, it was found that most of the red chili farmers in North Sumatra have applied

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several basic technologies such as the use of superior varieties and simple irrigation. However, the big challenge still lies in the lack of overall adoption of eco-friendly technology. Many farmers still rely on the overuse of chemical fertilizers which, in the long run, can damage soil fertility. This is in accordance with the findings (Fitria et al., 2024), which emphasizes that agricultural sustainability depends on the use of technologies that are able to maintain productivity while conserving natural resources. Post-harvest technologies, such as cold storage and good packaging, are also important in ensuring that red chili products can last longer and be marketed with good quality. Research by (Hidayat, 2024) shows that adequate storage infrastructure can reduce post-harvest losses which are often a major problem in the red pepper supply chain.

Farmer Institutions and Capacity Strengthening

Farmer institutions are one of the important pillars in the development of sustainable red chili agribusiness. Previous study by (Rahayu & Harahap, 2018) revealed that cooperatives and farmer groups can help farmers improve access to resources, information, and markets. In this study, it was found that farmer institutions in North Sumatra have played an active role in supporting red chili cultivation activities. Farmer cooperatives, for example, assist farmers in procuring agricultural inputs such as seeds, fertilizers, and pesticides at more affordable prices. In addition, cooperatives also play a role in strengthening the bargaining position of farmers in dealing with wholesalers and markets. However, the challenge faced by farmer institutions in the field is the lack of managerial capacity and skills in cooperative management. Many farmer groups are still dependent on external assistance, such as from the government or NGOs, and are not yet independent in managing their institutions effectively. This is in line with the findings (Uphoff, 1993), which emphasizes that strong farmer institutions must be able to manage themselves and have a solid organizational structure to ensure sustainability.

Supply Chain and Marketing

The red chili supply chain in North Sumatra involves many actors, ranging from farmers, collectors, traders, to end consumers in the local and national markets. According to (Anwar, 2013), an efficient supply chain requires good coordination between all parties involved, so that products can be distributed at low cost and on time. The study found that one of the main problems in the red chili supply chain is supply irregularities due to fluctuations in production affected by weather conditions and pest infestation. In addition, high transportation costs and lack of storage infrastructure cause the price of red chili to be highly volatile in the market. The price of red chili, which often fluctuates sharply, affects farmers' income, which tends to be unstable. As explained in the theory (Lillo et al., 2005), when production is abundant prices tend to fall, while when production decreases, prices will soar. In this situation, the contract farming approach suggested by (Rose & Yong, 2017) can be a solution to overcome price volatility. Through this scheme, farmers can sell their products at the price that has been agreed upon in the contract with the buyer, so that the risk of loss due to price fluctuations can be minimized. However, in this study, it was found that the implementation of contract farming in North Sumatra is still limited, so further support from the government and the private sector is needed.

Sustainable Agribusiness Estate Development Strategy

The model for the development of sustainable red chili agribusiness areas in North Sumatra Province must be designed by paying attention to various aspects that support the integration of economic, social, and environmental needs. This comprehensive approach is needed to ensure that every element in the red chili agribusiness chain can work synergistically, generating sustainable economic benefits, preserving the environment, and improving the welfare of farmers.

Sustainable Cultivation Technology

The cultivation technology used in the development of red chili agribusiness must focus on increasing productivity while preserving natural resources. Based on the results of this study, it was found that many farmers still use traditional cultivation techniques that are less than optimal and tend to damage the

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environment in the long term. Therefore, the application of modern environmentally friendly agricultural technology must be part of this development model. Technologies such as precision agriculture can be adopted to maximize efficient land use. For example, the use of drip irrigation systems can reduce water use and optimize nutrient uptake by plants. In addition, the implementation of an integrated pest management system can reduce farmers' dependence on chemical pesticides that have the potential to contaminate soil and water. Research by (Suryani & Dariah, 2012) It shows that environmentally friendly technologies, such as agroforestry systems and the use of organic fertilizers, are able to increase land productivity while reducing negative impacts on the environment. In the context of red chili agribusiness in North Sumatra, the application of this technology will help create a balance between high productivity and environmental sustainability. Counseling and technical training for farmers related to this technology is urgently needed to accelerate its adoption and application in the field.

Strengthening Farmer Institutions

Farmer institutions, such as farmer groups and cooperatives, play an important role in coordinating agribusiness efforts and increasing farmers' bargaining power in the market. Based on the results of this study, cooperatives in North Sumatra have shown great potential in helping farmers access agricultural inputs, obtain financing, and increase market access. However, there are still many farmer institutions that are not optimal in carrying out their roles, especially in terms of organizational management and business skills. A sustainable agribusiness development model must include strategies to strengthen farmer institutions, both in terms of human resources and managerial capacity. Research by (Uphoff, 1993) It shows that the success of farmer cooperatives is highly dependent on their ability to be independent and manage agribusiness businesses professionally. Therefore, the government and NGOs need to strengthen training programs to improve management capacity and business skills among farmers. In addition, institutional support should also include wider access to markets and distribution networks. A strong cooperative or farmer group can act as an aggregator, gathering the produce from its members and distributing it directly to a larger market, be it a regional, national, or even international market. In this context, cooperatives can also play a role in contract farming with the processing industry or large distributors, to ensure a market for farmers' red chili products and stabilize their income.

Efficient Supply Chain

The red chili supply chain in North Sumatra still faces many obstacles that interfere with its efficiency, including logistics problems, minimal storage infrastructure, and sharp price fluctuations. The sustainable agribusiness area development model must focus on improving this supply chain so that red chili products can be distributed faster, more cost-effectively, and with maintained quality. Research by (Anwar, 2013) shows that an efficient supply chain requires careful planning and coordination between all parties involved, from farmers, collectors, to distributors. One of the approaches that can be used in the development of red chili agribusiness areas is to build an agro-logistics center that functions as a center for the collection, storage, and distribution of red chili. This agro-logistics center can help farmers store crops in good condition, reduce post-harvest losses, and stabilize supply to the market throughout the year. In addition, it is necessary to build closer partnerships between farmers and market players. The study shows that one of the problems farmers face is price volatility in the market that is often unfavorable to them. The implementation of contract farming between farmers and wholesalers or distributors can be one of the solutions to reduce the risk of price fluctuations. Through this scheme, farmers can sell their crops at a price that has been agreed upon in advance, so that their income is more stable and guaranteed.

Government Policy Support

The role of the government is very important in creating a supportive environment for the development of sustainable red chili agribusiness areas. The government has a role in providing agricultural infrastructure, such as irrigation, access roads, and storage facilities, which are urgently needed by farmers. In addition, stable price policies and agricultural input subsidy programs are also important factors in maintaining the sustainability of farming businesses. (Todaro & Smith, 2020) mentioned that government intervention is needed to overcome market failure in the agricultural sector, where farmers are often faced with price

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uncertainty and unfair markets. In this context, the North Sumatra Provincial Government must be more proactive in supporting the marketing of red chili products through market promotion, opening new market access, and improving a transparent price information system. Government programs should also focus on strengthening local institutions and decentralization. The development of sustainable agribusiness estates cannot depend solely on national policies, but needs to be supported by local initiatives that understand the specific characteristics and needs of each region. Local governments are expected to play a more active role in building infrastructure, supporting education and training for farmers, and providing financing that is easily accessible to smallholders.

Environmental Sustainability in Agribusiness Development

The sustainability of red chili agribusiness is not only assessed from the economic and social side, but also from its environmental impact. This development model should prioritize ecologically sustainable approaches to prevent the degradation of natural resources that could threaten the production of red peppers in the future. One way to maintain environmental sustainability is to encourage the use of environmentally friendly conservation farming practices. Research by (Schaller, 1993) shows that sustainable agricultural practices that prioritize soil and water conservation, such as crop rotation, compost use, and water-saving irrigation techniques, can maintain land productivity in the long term. In North Sumatra, efforts to increase farmers' awareness of the importance of the environment need to be increased through more intensive counseling. In addition, the government must provide incentives for farmers who implement environmentally friendly practices, such as subsidies for organic fertilizers or assistance with green agricultural technology tools.

Synergy Between Stakeholders

The sustainable development model of red chili agribusiness areas requires synergy between stakeholders. All parties involved, including farmers, governments, business people, financial institutions, and NGOs, must work together in building a healthy agribusiness ecosystem. The success of this model depends on how well coordinated between various parties to achieve common goals, namely increasing productivity, maintaining environmental sustainability, and improving farmers' welfare. A multi-stakeholder approach should be the foundation of any agribusiness development program. Each stakeholder has complementary roles and responsibilities, so that this model can run effectively. For example, universities can play a role in agricultural technology research and innovation, while financial institutions provide financing support, and the government provides conducive policies and the necessary infrastructure. Overall, the model for the development of sustainable red chili agribusiness areas in North Sumatra should be based on the principles of strong collaboration, the application of innovative and environmentally friendly technologies, strengthening farmer institutions, supply chain efficiency, and responsive government policy support. Through the application of this model, it is hoped that agribusiness areas will be created that are able to survive in the long term, contribute to food security, and improve the local economy without sacrificing environmental sustainability.

Conclusion

The development of sustainable red chili agribusiness areas in North Sumatra Province is a crucial strategy in increasing agricultural productivity, farmers' economic stability, and food security. From the discussion above, it can be concluded that the success of this development model depends on several key aspects, namely the application of environmentally friendly cultivation technology, strengthening farmer institutions, supply chain efficiency, and comprehensive and sustainable government policy support. First, sustainable cultivation technology is needed to increase production without damaging natural resources. The application of precision agricultural techniques, efficient water management, the use of organic fertilizers, and integrated pest management have been proven to maintain a balance between productivity and environmental sustainability. Education and technology counseling to farmers need to be strengthened so that the adoption of this technology can run well. Second, strengthening farmer institutions such as farmer groups and cooperatives is very important in creating a structure that supports red chili farming.

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Strong institutions are able to help farmers access agricultural inputs, financing, and a wider market. In addition, this institution also plays an important role in coordinating production, distribution, and marketing activities, which will ultimately increase the competitiveness of farmers. Third, supply chain efficiency is the main challenge in maintaining price stability and availability of red chili products. Improvements in logistics infrastructure, such as the construction of storage and distribution centers (agro-logistics centers), as well as the implementation of contract farming schemes can reduce price fluctuations and post-harvest losses. With a more efficient supply chain, farmers will get more stable profits and the market will be filled with quality products throughout the year. Fourth, government policy support is urgently needed to create a conducive environment for the development of red chili agribusiness. The government needs to focus on providing agricultural infrastructure, fair price regulation, and farmer capacity building programs. This policy must be implemented in a sustainable manner and supported by synergy between the central and regional governments. Finally, environmental sustainability must be a top priority in the development of red chili agribusiness. Agricultural practices that damage the environment will threaten long-term productivity and disrupt local ecosystems. Therefore, efforts to preserve the environment through the use of environmentally friendly technology and incentives for farmers who implement green practices must be encouraged in a sustainable manner. Overall, the model of developing sustainable red chili agribusiness areas in North Sumatra requires strong collaboration between various stakeholders, ranging from farmers, the government, the private sector, to NGOs. With good synergy, the adoption of the right technology, strong institutions, efficient supply chains, and responsive policy support, this region has great potential to develop into a red chili production center that is able to contribute significantly to the regional and national economy, as well as create sustainable food security.

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