STRATEGY FOR DEVELOPING HORTICULTURE AGRICULTURAL PRODUCTION IN POLLUNG DISTRICT, HUMBANG HASUNDUTAN REGENCY

Abstract

This study explores strategies to enhance horticultural agricultural production in Pollung District, HumbangHasundutan Regency, a key area for the national Food Estate program. With unique agro-climatic conditions and existing challenges such as limited market access, inefficient production planning, and climate change impacts, this research aims to fill critical knowledge gaps in developing competitive and sustainable horticultural practices. Data was collected from primary sources, including key informants (farmers, agricultural officers, and local leaders), and secondary sources, such as government reports, analyzed using Location Quotient (LQ), SWOT analysis, and the Analytic Hierarchy Process (AHP). The study identifies priority commodities with high development potential, including chili, shallots, and oranges, based on LQ values, and highlights factors such as technology adoption, market diversification, and workforce skill enhancement as critical to success. Key strategies proposed include improving production quality through technology, diversifying products to meet consumer trends, and expanding market access via partnerships. These strategies are projected to boost productivity and competitiveness while ensuring ecological sustainability. The findings underline the need for targeted interventions, paving the way for future research into the implications of climate change and advanced farming innovations on horticulture.

Keywords: Horticulture, Location Quotient (LQ), SWOT, AHP, Development Strategy, Pollung District

I. Introduction

In the current era of trade liberalization and globalization, Indonesia faces new challenges and opportunities, particularly in the agricultural sector. With the removal of trade barriers between countries, the commodity market has expanded, offering significant opportunities for local commodities (Dewi, 2020 and Cha, 2024). However, the local market risks being flooded with imported commodities, which could ultimately harm farmers if local products cannot compete globally. According to the United Nations (2017), Indonesia's population is projected to reach 322 million by 2050, making it the fifth most populous country globally after China, India, Nigeria, and the United States. Under such conditions, policymakers may struggle to meet the food needs of the Indonesian population.

The paradigm of agricultural development has always evolved in line with human progress, technological advances, and scientific innovations (Gammachu, 2024). The agricultural sector has improved significantly both before and after the independence revolution, progressing from the early independence period through the reform era (Purwadaria, 2024). Agriculture is a vital component of the

national economy due to its strategic, resilient, articulate, progressive, and responsive characteristics (Simatupang&Syafaat, 2000). Economic development and planning are interconnected, with development planning serving as a useful tool to implement strategies through various action programs (Novita &Gultom, 2017). Such planning aims to optimize local resources into flagship products that can compete in local and international markets through well-designed strategies.

The agricultural sector is increasingly integrated, with a focus not only on cultivation but also on supporting aspects such as processing and marketing. This integration emphasizes agriculture's critical role in fulfilling human needs while leveraging natural and human resources. To remain competitive globally, the agricultural sector must innovate and enhance competitiveness, particularly in products with high potential and market value. Agriculture is a crucial component of national development, given its roles in providing food, feed, and energy (biofuel) (Ariningsih, 2015).

HumbangHasundutan Regency, an autonomous region in North Sumatra Province, covers an area of 235,264.37 hectares, comprising 233,769.46 hectares of land and 1,494.91 hectares of water. Located in central North Sumatra along the Bukit Barisan mountain range, the regency lies between 2°1'-2°28' North Latitude and 98°10'-98°58' East Longitude. HumbangHasundutan consists of 10 districts, 153 villages, and 1 urban village. In 2021, the regency's GDP at current prices (ADHB) reached IDR 6.356 trillion, contributed by 17 economic sectors (BPS, 2022). Pollung District in HumbangHasundutan Regency has substantial potential for horticultural production, particularly for crops such as potatoes, shallots, and garlic.

Since 2020, the government has designated HumbangHasundutan Regency as a location for the Food Estate program, aimed at strengthening national food security through the development of integrated horticultural areas. In Ria-Ria Village, Pollung District, 215 hectares of land have been developed for these crops, with plans to expand to 1,000 hectares. The program has positively impacted crop production and improved local economic conditions.

The global challenges posed by trade liberalization and climate change significantly affect the agricultural sector, with horticulture playing a critical role in food security and regional economic development. HumbangHasundutan Regency in North Sumatra, designated as a strategic site for Indonesia's national Food Estate program, faces unique challenges in achieving its full agricultural potential. Limited production planning, inadequate access to advanced farming technology, and vulnerability to climate change significantly impede the competitiveness of local horticultural commodities. Recent studies on sustainable agriculture emphasize the importance of adopting innovative strategies tailored to regional contexts to address such challenges (Marianti et al., 2017; Nugrahapsari et al., 2021).

Despite the government's interventions, including land allocation for horticulture and infrastructure improvements, the contributions of this region's horticultural sector to the gross regional domestic product (GRDP) remain suboptimal (BPS, 2022). Research in similar agricultural contexts highlights that integrated approaches involving technology adoption, market access expansion, and workforce development can enhance the sustainability of horticulture (Kasmin et al., 2023; Kiloes et al., 2019).

This study aims to bridge critical knowledge gaps by identifying priority horticultural commodities in Pollung District, analyzing their production potential using Location Quotient (LQ) analysis, and formulating comprehensive development strategies. These strategies, grounded in SWOT and AHP analyses, provide actionable solutions to increase productivity, foster sustainability, and strengthen the local economy. By leveraging Pollung's unique agro-climatic advantages, the research contributes to the broader discourse on sustainable agricultural practices.

The study concludes with clear recommendations for improving production capacity, addressing market constraints, and mitigating climate risks, thus advancing the goal of sustainable development in HumbangHasundutan.

II. Research Methodology

Research Location

This study was conducted in Ria-ria Village, Pollung District, HumbangHasundutan Regency, over a period of three months, from January to March 2024. The location was chosen because Ria-ria Village in Pollung District is a strategic national site for the food estate development program.

Research Informants

The informants for this study were selected using purposive sampling, a method of selecting participants based on specific criteria relevant to the research. The informants included:

1. Head of the Crop and Horticulture Division, Department of Agriculture and Food Security, HumbangHasundutan Regency.
2. Head of the Agricultural Extension Office, Pollung District, HumbangHasundutan Regency.
3. Agricultural Extension Officers in Pollung District.
4. Head of Farmer Groups in Ria-ria Village, Pollung District.
5. Five farmers from Ria-ria Village, Pollung District.

The number of farmer respondents (five) was determined using purposive sampling, focusing on individuals with direct experience in horticultural production in Ria-Ria Village, a pilot site for the Food Estate program. While this sample is minimal, it reflects the scope and resources of this preliminary study, which acknowledges the limited number of respondents as a research limitation. Future studies could expand the sample size for broader generalizability

Types and Sources of Data

This research employed qualitative data obtained from two sources:

1. **Primary Data**: Data collected directly from the field through observation, interviews, and questionnaires. These data were obtained from selected informants based on purposive sampling criteria and included perceptions, aspirations, and community participation.
2. **Secondary Data**: Data collected from official documents, reports, books, and relevant publications. Secondary sources included government documents, village records, and social media related to the research object.

Data Collection Methods

1. **Observation**:
   Conducted to gather direct data from the research location, focusing on activities, natural conditions, and social interactions in and around PuncakTangke Tabu.
2. **Interviews**:
   Used to extract in-depth information from informants about the potential and challenges of horticultural development.
3. **Documentation**:
   Involved collecting documents, photographs, and archives relevant to horticultural management in the research area.

Data Analysis Methods

1. **Qualitative Descriptive Analysis**:
   - Used to analyze observation and interview data.
   - Aims to describe the potential for horticultural production in PuncakTangke Tabu in detail.
2. **Location Quotient (LQ) Analysis**:
   - Identifies key horticultural commodities in Pollung District, HumbangHasundutan Regency, using the Location Quotient (LQ) method.
   - LQ is widely applied to identify industries or economic sectors based on regional potential.
   - Helps determine the distribution of commodities and classify regions according to their potential.

   In addition to LQ, Dynamic Location Quotient (DLQ) was utilized to assess the comparative advantage trends of horticultural commodities over a specified time frame (2016–2020). This dynamic approach provides a longitudinal perspective on competitiveness, highlighting commodities with consistent advantages or emerging potential.

   LQ values were calculated using horticultural production data from 2016 to 2020, sourced from the Department of Agriculture and Food Security (2022). The formula compares the proportion of a commodity's production in Pollung District to the overall production in HumbangHasundutan Regency. This five-year dataset ensures robust insights into the comparative advantages of specific crops.

3. **SWOT Analysis**:
   - Compares internal factors (strengths and weaknesses) with external factors (opportunities and threats).
   - Maps results into four quadrants to determine appropriate strategies:
     - Quadrant 1: Supports aggressive strategies.
     - Quadrant 2: Represents diversification strategies, utilizing opportunities to overcome weaknesses.
     - Quadrant 3: Reflects defensive or minimization strategies to address weaknesses and threats cautiously.
     - Quadrant 4: Defense or concentration strategies using

strengths to avoid threats.

The SWOT analysis followed a structured procedure outlined by Marianti et al. (2017), integrating internal factors (strengths and weaknesses) with external factors (opportunities and threats). These factors were identified through stakeholder consultations and scored based on their relevance to horticultural development in Pollung District. The results were mapped into four strategic quadrants to identify actionable strategies.

4. **Analytic Hierarchy Process (AHP)**:
    - Results from AHP analysis prioritize strategies for horticultural development, including:
        - Strengthening distribution and marketing systems to expand market access.
        - Providing technical training to farmers to enhance productivity and efficiency.
        - Implementing environmentally friendly technologies to maintain ecosystem sustainability.

Operational Definitions

- **Production Potential**: Measures land capacity, agro-climatic suitability, horticultural crop productivity, and potential yield improvements.
- **Infrastructure Development**: Assesses the availability and quality of supporting facilities, such as irrigation, road access, farming tools, and post-harvest infrastructure.
- **Attraction**: Evaluates the appeal of horticultural sectors, including product uniqueness, agrotourism potential, and contributions to the local economy.
- **Accessibility**: Measures transportation ease to production sites and markets, including road infrastructure quality and connectivity.
- **Amenity**: Assesses supporting facilities such as storage warehouses, training centers, and market amenities that aid production management.
- **Ancillary**: Measures organizational or farmer group support, cooperative presence, and technical assistance programs that facilitate horticultural management.
- **Safeness**: Evaluates protections for harvests, infrastructure, and farmers from risks such as theft, pest attacks, or natural disasters.
- **Comfort**: Measures cleanliness, working environment conditions for farmers, and technology applications supporting productivity and sustainability.

Attraction, accessibility, amenity, ancillary, safeness, and comfort were evaluated as part of a comprehensive assessment framework to ensure the sustainability and viability of horticultural production. These criteria reflect dimensions such as market appeal (attraction), logistical feasibility (accessibility), and farmer well-being (safeness and comfort), which are essential for formulating holistic development strategies in the context of rural agricultural systems.

This research methodology is designed to produce strategies for horticultural production development in Pollung District that align with sustainability principles, offering economic and ecological benefits for local communities and the broader region.Recent research supports the use of these methodologies in

similar agricultural contexts (Marianti et al., 2017; Rozali et al., 2023), reinforcing their relevance for this study.

III. Result and Discussion

HumbangHasundutan Regency, located in the Bukit Barisan region, has suitable topography and climate for horticultural cultivation. Covering an area of 235,264.37 hectares, including 233,769.46 hectares of land, the regency consists of 10 districts, including Pollung District, which holds significant potential for horticultural commodity development.

Based on BPS (2022) data, the GRDP at current prices (ADHB) of HumbangHasundutan Regency reached IDR 6.356 trillion in 2021, derived from contributions by 17 business sectors. The largest contributor was the agriculture, livestock, forestry, and fisheries sector, accounting for 43.38% of the total GRDP. Other contributors included wholesale and retail trade, motor vehicle and motorcycle repair (16.09%), and construction (14.48%). This highlights the vital role of these sectors in the regional economy. Pollung District, in particular, has significant potential for horticultural commodity development.

During the 2016–2020 period, horticultural production in HumbangHasundutan Regency is detailed in **Table 1** below:

Table 1. Horticultural Crop Production in HumbangHasundutan Regency, 2016–2020 (tons)

No.	Commodity	2016	2017	2018	2019	2020
1	Red Chili/Large Chili	4,586.00	5,553.50	3,927.00	4,013.00	4,592.65
2	Bird's Eye Chili	1,541.30	2,007.10	1,413.50	1,461.70	2,435.78
3	Shallots	1,015.30	1,378.40	1,580.20	1,534.50	5,367.70
4	Potatoes	1,707.20	2,180.90	4,282.00	3,851.10	5,975.00
5	Cabbage	5,389.10	5,087.10	6,306.00	5,102.70	6,906.20
6	Mustard Greens	1,304.10	1,157.70	1,293.50	1,577.80	1,786.40
7	Tomatoes	5,683.90	3,684.70	4,088.20	7,849.90	6,451.50
8	Carrots	1,233.30	1,328.10	1,697.60	1,779.40	2,545.70
9	Green Beans	499.10	340.00	567.70	382.20	367.30
10	Long Beans	320.20	285.40	367.60	189.60	220.30
11	Leeks	1,200.30	114.20	1,356.90	1,454.80	855.30
12	Cauliflower	926.60	1,161.90	1,342.50	1,502.90	1,037.40
13	Eggplant	450.80	408.50	536.80	609.80	351.30
14	Cucumbers	685.40	353.10	454.80	487.20	423.40
15	Water Spinach	59.80	51.40	192.20	310.80	86.40
16	Spinach	99.80	98.10	157.50	151.60	82.50
17	Garlic	0.00	0.00	0.00	219.90	666.30
18	Oranges	1,420.10	2,488.50	5,509.40	6,661.20	6,825.65
19	Mangoes	48.80	85.20	196.10	110.00	412.90

No.	Commodity	2016	2017	2018	2019	2020
20	Durian	3,298.90	11,328.00	26,913.80	16,209.10	16,520.77
21	Salak	5,861.80	11,328.00	26,913.80	16,209.10	16,520.77
22	Tiung	316.00	201.50	201.50	0.00	136.00
23	Avocado	371.40	425.80	590.60	734.80	789.99
24	Pineapples	122.40	330.80	654.10	938.50	938.50
25	Passion Fruit	12.70	35.20	28.50	12.50	12.50
Total		38,154.30	51,413.10	90,571.80	73,354.10	82,308.21

Source: Department of Agriculture and Food Security, 2022

In 2020, the total horticultural production in Pollung District reached 6,894.41 tons, while the total horticultural production in HumbangHasundutan Regency was recorded at 82,308.21 tons. To determine the comparative advantage of commodities, Location Quotient (LQ) calculations were performed for each commodity, including "Red Chili/Large Chili." The production of Red Chili in Pollung District in 2020 reached 717 tons, contributing significantly to the district's total horticultural production. On a broader scale, the production of Red Chili in HumbangHasundutan Regency amounted to 4,592.65 tons. Calculating the LQ for Red Chili resulted in a ratio of 0.10398 for production in Pollung compared to its total horticultural production and a ratio of 0.05578 for production in HumbangHasundutan Regency.

Horticultural crop production in Pollung District, HumbangHasundutan Regency, during the 2016–2020 period is detailed in **Table 2** below:

Table 2 Horticultural Crop Production in Pollung District, 2016–2020 (tons)

No.	Commodity	2016	2017	2018	2019	2020
1	Red Chili/Large Chili	824.1	524.0	281.3	526.0	717.0
2	Bird’s Eye Chili	139.6	146.0	102.6	142.6	481.7
3	Shallots	0.0	3.4	36.0	166.0	1,450.0
4	Potatoes	46.0	120.0	445.0	1,180.0	370.0
5	Cabbage	132.0	207.0	218.0	660.0	886.5
6	Mustard Greens	6.0	17.0	38.5	135.0	112.0
7	Tomatoes	770.5	484.4	1,120.0	662.5	1,127.5
8	Carrots	12.0	0.0	0.0	0.0	30.0
9	Green Beans	0.0	0.0	0.0	0.0	4.5
10	Long Beans	2.0	0.0	0.0	0.0	4.6
11	Leeks	7.5	0.0	0.0	15.5	36.0
12	Cauliflower	0.0	0.0	218.0	0.0	0.0
13	Eggplant	2.3	0.0	0.0	0.0	7.0
14	Cucumbers	0.0	0.0	0.0	0.0	8.0
15	Water Spinach	0.0	0.0	0.0	0.0	4.0
16	Spinach	0.0	0.0	0.0	0.0	3.0

No.	Commodity	2016	2017	2018	2019	2020
17	Oranges	95.6	222.4	279.3	345.5	863.1
18	Tiung	13.32	60.6	60.6	85.0	115.0
19	Avocados	116.5	118.2	125.1	165.0	239.06
20	Pineapples	18.4	110.7	331.0	617.6	435.45
Total		2,185.82	2,013.70	3,255.40	4,700.70	6,894.41

Source: Department of Agriculture and Food Security, 2022

Based on the calculations, commodities with an LQ value greater than 1 are categorized as base commodities in Pollung District in 2020. Examples of these base commodities include Red Chili/Large Chili (LQ = 1.864), Bird's Eye Chili (LQ = 2.361), Shallots (LQ = 3.225), Oranges (LQ = 1.51), Avocados (LQ = 3.61), and Pineapples (LQ = 5.54). These base commodities demonstrate significant local advantages compared to overall production in HumbangHasundutan Regency and should be prioritized in formulating agricultural development strategies for the region.

3.2 Discussion

SWOT Analysis of Horticultural Production Development

Through a SWOT analysis, various strategies have been identified and designed to optimize internal and external potential for horticultural development in Pollung District. These strategies focus on leveraging existing strengths, mitigating weaknesses, capitalizing on market opportunities and government support, and addressing threats that may hinder horticultural sector development. The SWOT analysis based on respondents' responses and ratings is presented in **Table 3** below:

Table 3 SWOT Analysis Based on Respondents' Responses and Ratings

No.	Statement	Respondents	Avg Rating	
		1 2 3 4 5		
A. Strengths				
1	Knowledge and Expertise	3 3 2 3 3	2.2	2
2	Technology and Innovation	3 3 2 3 3	2.2	2
3	Productivity	3 3 3 3 3	2.4	2
4	Product Quality	3 3 3 3 3	2.4	2
5	Natural Resources	3 3 3 3 3	2.4	2
B. Weaknesses				
1	Production Planning	2 2 2 2 2	1.6	2
2	Skilled Workforce	2 2 3 3 3	2.0	2
3	Pest Control and Maintenance	2 2 2 2 2	1.6	2
4	Product Diversification	2 2 2 2 2	1.6	2
C. Opportunities				
1	Market Demand	3 3 3 2 3	2.2	2

No.	Statement	Respondents	Avg	Rating
2	Government Support	4 3 3 3 3	2.6	3
3	Access to New Markets	2 3 3 2 3	2.0	2
4	Organic Product Demand	3 3 2 2 3	2.0	2
5	Consumer Trends	3 3 3 3 3	2.4	2
6	Product Innovation	3 3 3 3 3	2.4	2
D. Threats				
1	Climate Change	2 2 2 2 1	1.6	2
2	Government Policies	1 2 2 2 2	1.4	1
3	Competition	1 2 1 2 2	1.2	1
4	Production Costs	2 2 — 1 2	1.0	1
5	Resource Availability	2 2 1 2 2	1.4	1
6	Access to Technology	2 2 1 2 2	1.4	1

This table presents the results of respondents' evaluations of the SWOT factors influencing horticultural development in Pollung District. The analysis is divided into four main categories: Strengths, Weaknesses, Opportunities, and Threats. Each category includes statements related to specific factors, such as "Knowledge and Expertise" under Strengths and "Production Planning" under Weaknesses.

Respondents' assessments are rated on a scale of 1 to 4, depending on the type of SWOT factor being evaluated.

- For **Strengths** and **Opportunities**, a rating of 4 represents "Very Strong" (VS), 3 "Strong" (S), 2 "Not Strong" (NS), and 1 "Very Weak" (VW).
- Conversely, for **Weaknesses** and **Threats**, the scale is reversed, with 4 indicating "Very Weak" and 1 indicating "Very Strong."

The "Average" (Avg) column shows the mean score assigned by respondents for each statement, offering a general perception of the importance of each factor. The "Rating" column simplifies prioritization, helping to identify critical factors for the SWOT analysis. High scores in Strengths and Opportunities suggest potential areas for optimization, while high scores in Weaknesses and Threats indicate aspects that require greater attention to mitigate their impact on horticultural development in Pollung District.

Table 4Respondents' Assessment of SWOT Factors in the IFAS Matrix

No.	Factor	Weight	Rating	Score
A. Strengths				
1	Knowledge and Expertise	0.15	2	0.3
2	Technology and Innovation	0.12	2	0.24
3	Productivity	0.10	2	0.2
4	Product Quality	0.08	2	0.16
5	Natural Resources	0.10	2	0.2
Sub-Total	0.55	10	1.1	

No.	Factor	Weight	Rating	Score
B. Weaknesses				
1	Production Planning	0.15	2	0.3
2	Skilled Workforce	0.12	2	0.24
3	Pest Control and Maintenance	0.10	2	0.2
4	Product Diversification	0.08	2	0.16
Sub-Total	0.45	8	0.9	
Total	1.00	18	2.0	

Table 4 presents respondents' assessments of factors included in the Internal Factor Analysis Summary (IFAS) Matrix, encompassing Strengths and Weaknesses that affect horticultural development in Pollung District. Each factor is assigned a weight reflecting its importance, followed by a rating representing respondents' evaluation of the strength or weakness of each factor. The score is calculated as the product of the weight and rating.

In **Section A: Strengths**, five factors are evaluated: Knowledge and Expertise, Technology and Innovation, Productivity, Product Quality, and Natural Resources. These factors collectively have a total weight of 0.55, indicating their combined significance for horticultural development potential. Similarly, **Section B: Weaknesses** evaluates four factors: Production Planning, Skilled Workforce, Pest Control and Maintenance, and Product Diversification, with a total weight of 0.45.

The **rating column** reflects respondents' perceptions, while the **score column** represents each factor's contribution to horticultural development based on its weight and rating. The total score provides an overall view of internal conditions influencing horticultural development in Pollung District and serves as the basis for developing more effective strategies.

Table 5 Respondents' Assessment of SWOT Factors in the EFAS Matrix

No.	Factor	Weight	Rating	Score
A. Opportunities				
1	Market Demand	0.15	2	0.3
2	Government Support	0.12	3	0.36
3	Access to New Markets	0.10	2	0.2
4	Organic Product Demand	0.08	2	0.16
5	Consumer Trends	0.07	2	0.14
6	Product Innovation	0.05	2	0.1
Sub-Total	0.57	13	1.26	
B. Threats				
1	Climate Change	0.12	2	0.24
2	Government Policies	0.10	1	0.1
3	Competition	0.08	1	0.08
4	Production Costs	0.07	1	0.07

No.	Factor	Weight	Rating	Score
5	Resource Availability	0.04	1	0.04
6	Access to Technology	0.02	1	0.02
Sub-Total	0.43	7	0.55	
Total	1.00	20	1.81	

Table 5. presents respondents' assessments of factors included in the External Factor Analysis Summary (EFAS) Matrix, focusing on Opportunities and Threats that influence horticultural development in Pollung District.

In **Section A: Opportunities**, six factors are evaluated, including Market Demand, Government Support, Access to New Markets, Organic Product Demand, Consumer Trends, and Product Innovation. These opportunities collectively have a total weight of 0.57, suggesting their potential to enhance productivity and competitiveness.

In **Section B: Threats**, six factors are considered: Climate Change, Government Policies, Competition, Production Costs, Resource Availability, and Access to Technology, with a total weight of 0.43, highlighting challenges that may hinder horticultural development.

The **rating column** reflects respondents' perceptions of each factor's influence, while the **score column** represents the contribution of each factor based on its weight and rating. This evaluation provides a clear understanding of external conditions impacting the horticultural sector and informs the development of strategies to leverage opportunities and mitigate threats.

Recommended Strategies

1. **Improving Quality and Technology in Production**
   Maximize the use of existing technology and knowledge in the horticultural sector to enhance product quality and meet market standards. Innovations in land management, irrigation systems, and product development can increase competitiveness locally and nationally.
2. **Product Diversification Based on Consumer Trends**
   Utilize opportunities from consumer trends favoring organic and eco-friendly products by developing a variety of products that align with market demands, reducing reliance on a single product type.
3. **Enhancing Workforce Capacity and Skills**
   Support productivity and efficiency by prioritizing agricultural technology training for the workforce, enabling adaptation to modern technology and higher production demands.
4. **Expanding Market Access Through Partnerships and Government Support**
   Leverage government support to establish partnerships locally and internationally, broadening the market share of horticultural products.
5. **Strengthening Branding for Local Horticultural Products**
   Build a unique identity for Pollung's horticultural products to enhance their market appeal. Strong branding provides a competitive edge, particularly for premium products emphasizing quality and local knowledge.

These strategies aim to maximize internal strengths and external opportunities, ensuring sustainable and competitive development in Pollung District's horticultural sector.

Strategy Analysis for Horticultural Production Development Using the Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a decision analysis approach developed by Thomas L. Saaty in the 1970s. It is used to address complexity and uncertainty in decision-making involving multiple criteria. AHP is part of the Multi-Criteria Decision Making (MCDM) framework, which handles situations with competing criteria. The method organizes decision elements into a hierarchical structure and uses pairwise comparisons to determine the relative weights of each element (Rozali et al., 2023).

To identify the most appropriate strategy for optimizing internal strengths and external opportunities, the AHP method is applied. AHP provides a systematic approach for evaluating and prioritizing strategic alternatives based on relevant criteria. This method enables pairwise comparisons among criteria, including internal factors such as human resource quality and infrastructure capacity, and external factors like market trends and government policies. By calculating relative weights derived from the comparison matrix, AHP objectively and measurably ranks strategic alternatives. Thus, AHP supports selecting the most effective and efficient strategies to optimize the horticulture sector's potential in Pollung District, addressing challenges, and leveraging opportunities.

Illustrates the hierarchy of criteria and sub-criteria used in the Analytic Hierarchy Process (AHP) to determine priority strategies for developing horticultural production in Pollung District. The diagram is divided into five main criteria, each with three specific sub-criteria. Below is an explanation of each criterion and its sub-criteria:

1. **Improving Production Quality and Technology**
    - Focuses on technological and quality development in horticultural production to enhance efficiency and output.
    - **Land Management Technology**: Innovations in effective and environmentally friendly land management.
    - **Irrigation Systems**: Implementation of more efficient irrigation systems to ensure optimal water availability.
    - **Product Innovation**: Development of new products or enhancement of existing ones to increase value and competitiveness.
2. **Product Diversification Based on Consumer Trends**
    - Highlights the importance of diversifying products to align with dynamic market demands.
    - **Organic Products**: Environmentally friendly, pesticide-free horticultural production.
    - **Eco-Friendly Products**: Products manufactured using methods that promote environmental sustainability.
    - **New Product Variants**: Development of more innovative and market-attractive product variants.
3. **Enhancing Workforce Capacity and Skills**

- Aims to improve workforce skills and capacity to better prepare for challenges in the horticulture sector.

4. **Market Expansion Through Partnerships and Government Support**
   - Focuses on developing market networks and leveraging government policies to expand the market share of horticultural products.
5. **Strengthening Branding of Local Horticultural Products**
   - Emphasizes the importance of building the identity and quality of horticultural products to enhance market value.

By using these criteria and sub-criteria, the AHP analysis helps determine the most effective strategies to develop horticultural production in the region.

Key Findings and Implications

This study highlights the significant potential of Pollung District for horticultural development, particularly for priority commodities such as chili (red and bird's eye), shallots, oranges, avocados, and pineapples. These commodities, with LQ values exceeding 1 and consistent DLQ trends, demonstrate a comparative advantage for sustainable production and economic growth in the region.

The findings underscore several critical implications:

1. **Economic Growth**: Developing these priority commodities can enhance regional economic contributions to the GRDP of HumbangHasundutan Regency, supporting the broader goals of the Food Estate program.
2. **Sustainability**: By incorporating environmentally friendly technologies and diversifying products based on consumer trends, the strategies proposed in this research promote ecological sustainability while addressing market demands.
3. **Policy and Practice**: The study's strategic recommendations, including expanding market access through partnerships and improving workforce skills, provide actionable pathways for policymakers and local agricultural stakeholders to enhance competitiveness.

Limitations

While this study offers valuable insights, several limitations should be acknowledged:

1. **Sample Size**: The research relied on a minimal number of farmer informants due to resource constraints. This limitation may affect the generalizability of findings to the broader farmer population in the region.
2. **Data Scope**: The analysis focused on a five-year dataset (2016–2020), which may not fully capture long-term trends or the effects of recent interventions, such as the Food Estate program.
3. **Methodological Constraints**: Although LQ and DLQ analyses provide robust indicators of comparative advantage, additional methods such as stochastic frontier analysis could complement these insights by assessing efficiency levels.

Future Research Directions

To build on this study's findings, future research should:

1. **Expand Sampling**: Conduct surveys with a larger, more representative sample of farmers to validate and refine the identified strategies.

2. **Longitudinal Analysis**: Incorporate more recent and longitudinal data to evaluate the impact of ongoing agricultural policies and programs on horticultural development.
3. **Impact of Climate Change**: Explore the effects of climate variability on the productivity and sustainability of priority commodities in Pollung District, using predictive models and scenario analysis.
4. **Advanced Methods**: Utilize advanced econometric or geospatial techniques to assess efficiency, resource allocation, and spatial dynamics in horticultural production.

IV. Conclusion and Recommendations

Desa Ria-Ria in Pollung District, HumbangHasundutan Regency, holds significant potential to become a leading food estate area in North Sumatra. Several horticultural commodities in Pollung District, such as Red Chili/Large Chili, Bird's Eye Chili, Shallots, Oranges, Avocados, and Pineapples, demonstrate comparative advantages with Location Quotient (LQ) values greater than 1. These commodities are prioritized for development. Conversely, non-base commodities like Potatoes, Mustard Greens, Carrots, and Green Beans, with LQ < 1, require efforts to enhance competitiveness through innovation and quality improvements. The priority commodities in Pollung District have substantial potential to increase production and farmers' income. However, challenges such as limited production management, restricted market access, a lack of skilled labor, and the impacts of climate change require special attention. Development should focus on optimizing production capacity, modern technology, and human resource training.

Based on the SWOT and AHP analyses, five priority strategies were identified:

1. **Improving Quality and Production Technology**: Focus on modernizing production techniques to increase efficiency and meet market standards.
2. **Product Diversification Based on Consumer Trends**: Develop new and varied products to reduce dependence on single-product markets.
3. **Enhancing Workforce Capacity**: Train farmers and workers to adopt innovative agricultural technologies and respond to market demands.
4. **Strengthening Local Product Branding**: Create a unique identity for Pollung's horticultural products to enhance market appeal.
5. **Expanding Market Access Through Partnerships and Government Support**: Build collaborations and leverage government programs to open broader market opportunities.

For sustainable development of superior horticultural commodities such as Red Chili/Large Chili, Bird's Eye Chili, Shallots, Oranges, Avocados, and Pineapples, which have LQ values above 1, these should be prioritized. Improving quality and applying modern agricultural technology should be the main focus for these commodities to enhance competitiveness and ensure sustainable production. Commodities with LQ values below 1, such as Potatoes, Mustard Greens, Carrots, and Green Beans, require special attention to boost their competitiveness. Innovations in cultivation techniques, product diversification, and quality improvements should be implemented to enable these commodities to compete in broader markets. Additionally, improving supporting infrastructure, such as market access and agricultural technology, should be prioritized to address issues

related to limited production planning and skilled labor shortages. Comprehensive training for farmers and workers is essential to adopt efficient agricultural technologies and overcome challenges such as climate change impacts on agricultural yields.

COMPETING INTERESTS:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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