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Selected Locations for Potato Industry Cultivation in Indonesia using the Weighted Product Method

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ABSTRACT

PT. ABCD, the world's largest potato chip maker, relies on industrial-grade potatoes grown in conjunction with Indonesian farmers. This study addressed the topic of selecting the best subdistrict locations for industrial potato growing by combining agroclimatic and non-agroclimatic variables. The goal was to determine the best cultivation areas based on agroclimatic variables (temperature, rainfall, sunlight duration, cloud cover, radiation, altitude, frost risk) and non-agroclimatic variables (harvested area, production, productivity, logistics, pest and disease incidence, irrigation, production costs, competition, and farmer capability). The Weighted Product (WP) technique was used in the study to assign weights to each criterion and evaluate alternatives through a ranking procedure. Data were gathered from PT ABCD's agroclimatic database (2010−2020) and processed using ArcGIS, supplemented by secondary data from the Central Bureau of Statistics and field surveys. The results identify the ten most suitable subdistricts for industrial potato cultivation as Batur (Banjarnegara, Central Java), Tosari (Pasuruan, East Java), Pasir Wangi (Garut, West Java), Cikajang (Garut, West Java), Sirampog (Brebes, Central Java), Pejawaran (Banjarnegara, Central Java), Bawang (Batang, Central Java), Kayu Aro (Kerinci, Jambi), Pangalengan (Bandung, West Java), and Kejajar. The study shows that the WP technique efficiently incorporates agroclimatic and non-agroclimatic factors in site selection. These findings provide a solid foundation for strategic decision-making in the potato chip sector, helping to identify appropriate cultivation areas to assure long-term supply and competitiveness.

Keywords: chip grade, potato cultivation, land evaluation, agroclimatic variables, weighted product method

INTRODUCTION

Potato chip consumption is increasing in developing nations, particularly Indonesia, due to the adoption of Western dietary patterns, economic expansion, the rise of the middle class, and urbanization (IMARC 2018). This trend has presented both benefits and challenges for the potato chips sector, notably in terms of ensuring a regular supply of high-quality raw materials. Demand for industrial-quality potatoes (chips grade) is increasing in tandem with the industry's expansion (Asgar 2013). The Indonesian potato chip industry was valued at around IDR 2 trillion in 2022 and is expected to expand at a compound annual growth rate of 8.1% between 2023 and 2028 (Statista, accessed on October 1st, 2023). Large corporations such as Indofood Group, Calbee-Wings, Garuda Food, and PepsiCo dominate the market, accounting for 90% of the total, with small-scale household industries accounting for the remaining 10%.

Despite this demand, Indonesia ranks 37th internationally in potato production, producing 1.36 million tons in 2021 (FAO 2023). In comparison, China, India, Ukraine, the United States, and Russia are the leading producers, with yields much exceeding those of Indonesia. National productivity averages 19−20 tons per hectare, which is much lower than in countrys like Australia, New Zealand, Germany, Scotland, the Netherlands, and Belgium, where yields are around 40 tons per hectare. Potato agriculture in Indonesia is concentrated in the highlands of East Java, West Java, Central Java, North Sumatra, Jambi, West Sumatra, South Sumatra, Bengkulu, North Sulawesi, South Sulawesi, and West Nusa Tenggara, where ideal agroclimatic conditions support production.

Large-scale processors, such as PT ABCD, the world's biggest producer of potato chips under the trademark XYZ, require consistent access to industrial-quality potatoes. This supply is met by a combination of imports and local sourcing, in collaboration with Indonesian farmers. To ensure sustainability and economic efficiency, suitable local agriculture regions must be identified considering both agroclimatic and non-agroclimatic aspects.

The goal of this study is to identify suitable potato cultivation sites in Indonesia at the subdistrict level to ensure a long-term supply of industrial-grade raw materials. The Weighted Product (WP) approach was used to rank land suitability by combining agroclimatic

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and non-agroclimatic characteristics, resulting in recommendations for location-specific cultivation practices.

METHODS

This study used a non-experimental design with both internal and secondary data sources. Internal agroclimatic data from potato production centers were collected using PT ABCD's ArcGIS system, and included variables such as average daily temperature, daytime and nighttime temperatures, diurnal temperature variation, rainfall, sunshine duration, cloud cover, solar radiation, altitude, and frost risk. Secondary non-agroclimatic data were gathered from the Central Bureau of Statistics (Biro Pusat Statistik, BPS) and field surveys conducted during the study period, which included harvested area, production volume, productivity levels, travel time, pest and disease incidence, irrigation conditions, potato production costs, competition in the potato chips industry, and farmer capacity. The evaluation criteria were weighted based on expert interviews with PT. ABCD's internal professionals and external partners.

Research Period and Location

The research was carried out between July 2023 and October 2023 at PT ABCD, which is situated in Jakarta. Field survey data were gathered during site visits to potato growers in several production areas in Indonesia. As research samples, 53 subdistricts were chosen from around the country to reflect key potato producing centers.

Research Material

The research materials included agroclimatic data (5 × 5 km² grid) for 2010-2020 from PT ABCD's Climate Risk Analysis software, land elevation data from Google Maps, non-agroclimatic factors from the BPS, and field survey results. Figure 1 shows a screenshot of the Climate Risk Analysis software, which was developed by PT ABCD and was based on the ArcGIS platform.

Data Analysis

The data was analyzed using descriptive statistics and the Weighted Product (WP) method. Calculations were performed using Microsoft Excel 2021, classifying criteria factors as either advantages or costs (conflicting criteria), and determining the product of alternative criterion values with their associated weights. The weighted multiplication method, or WP method, is one of the approaches in Multi-Criteria Decision Making (MCDM) (Andika *et al.* 2019). The approach involved establishing criteria as benefits or costs and then calculating the weighted product of different criterion values (Mahardika *et al*. 2017). Figure 2 shows the structure of the Weighted Product Method, which describes the sequence of computing steps used in the study.

The criteria and weighting were determined using the opinions of the company's internal and external specialists. The specialists consulted were (1) Mohammad Farooq, MBA, Agro Director of PT ABCD, with over 15 years of experience in industrial potato production; (2) Ir. Diky Indrawibowo is Director of PT Bumi Agro Teknologi, a potato seed breeder; and (3) Ir. Adhi Wihardi is Director of PT Pandu Agro Potato, specializes in industrial potato farming partnerships.

RESULTS AND DISCUSSION

Potato (*Solanum tuberosum* L.) is a horticultural crop from the Solanaceae family. Pitojo (2004) described its taxonomic classification as follows: Class Dicotyledonae, Order Tubiflorae, Family Solanaceae,

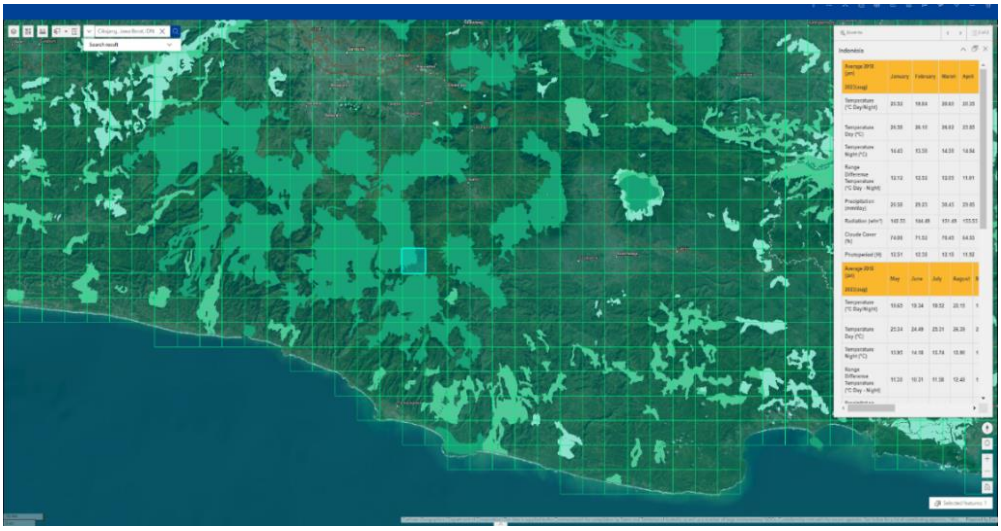

Figure 1 Screenshot of Agroclimatic Data (5 × 5 km² Grid) in the ArcGIS–Based Agroclimatic System.

Genus Solanum, and Species *Solanum tuberosum* L. Potato tubers begin to form in the soil approximately three weeks after planting, and tuber growth continues as the plant's leaves remain green. Tuber maturity begins when the leaves turn yellow and dry, and it continues until the tubers are fully ripe. Potatoes can be harvested 90−160 days after planting, once around 75% of the leaf has dried. Immaturely harvested potatoes have thin, brittle skin, high water content, and low starch levels; mature potatoes have thicker skin, higher starch content, greater resistance to injury, and longer storage capacity (Diwa *et al.* 2015).

Potato cultivation in Indonesia mainly follows a rainy season cycle, with planting taking place two to three times per year. Most farmers grow potatoes twice a year, often alternating with other crops or leaving the field fallow until the next planting season. Land selection is critical to the success of potato farming in achieving maximum yields. According to Baja (2012), land appraisal is critical for determining the potential of land usage and reaching peak output. Lopulisa and Husni (2011) underline that site selection should consider two key factors: physical resources (soil, topography, and climate) and socioeconomic resources (land ownership, management level, labor availability, markets, and other human activities). Agroclimatic factors are the quantitative relationship between crop growth and development processes and the prevalent climatic conditions of a location (Kelgenbaeva & Buchroithner 2003). Highland regions around 1,000−3,000 m above sea level are thought to be ideal for potato farming (Djoemaijah *et al*. 2000).

Tuber formation is best achieved in a cold climate with an average daily temperature of 15−18°C, short photoperiods, and high light intensity or brightness. Potatoes grow best at temperatures below 30°C during the day and below 20°C at night. Elevated daytime temperatures cause photorespiration, reducing photosynthetic activity, whereas elevated nighttime temperatures reduce assimilate translocation to tubers and increase translocation to leaves and stems, resulting in decreased starch concentration in tubers (Muhibuddin 2016). Potatoes require a yearly rainfall of 2,000−3,000 mm, or 160−250 mm per month (Kementan 2011). Photosynthesis requires 9−10 hours of daylight each day, which has a significant impact on tuber start and development (Samadi 2007). The optimal radiation level for photosynthesis is around 209.3−558.2 W/m², with maximum photosynthesis at 300 W/m². High cloud cover relates to poorer production and productivity levels (White & Izquerdo 1993). Yield differences are particularly large between normal and frost conditions, reducing farmers' profitability. Frost episodes can render up to 61% of potato fields unharvestable, with crop age influencing the magnitude of farmer losses (Arsyadah & Harini 2018). The weighting of agroclimatic preference values was derived based on the compatibility of agroclimatic characteristics with potato crop requirements at each growth stage (GS I-GS V), as shown in Table 1.

Subdistrict data are transformed into alternatives or vectors during WP computation. Each month, the weights of each criterion and agroclimatic factor (average temperature, daytime temperature, nighttime

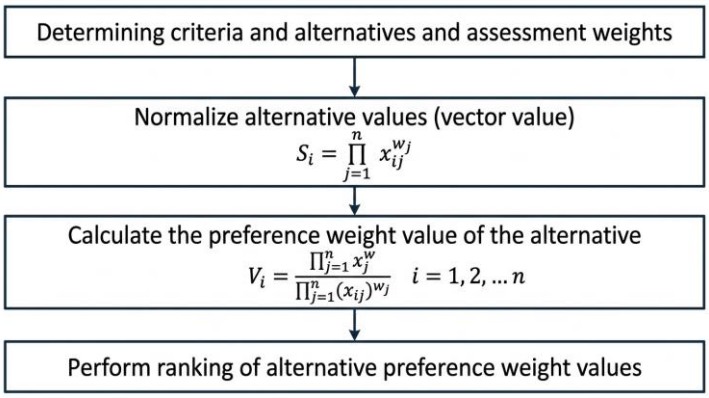

Figure 2 Framework of the weighted product method.

Table 1 Potato planting season patterns and growth stages (GS)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Augu	Sep	Oct	
	Planting season I		Planting season II							Planting seas	
1)	XX	XX	GS I-GS II	GS III-GS IV	GS IV	GS V	XX	XX	GS I-GS II	GS III-GS IV	
2)	GS V	XX	XX	GS I-GS II	GS III-GS IV	GS IV	GS V	XX	XX	GS I-GS II	G

Remarks: [1)] Early planting period; [2)] Late planting period; XX : Fallow or intercrop; GS I (0–15 DAP): Shoot growth; GS II (15–30 DAP): Vegetative growth; GS III (30–45 DAP): Early tuber formation; GS IV (45–90 DAP): Tuber growth and enlargement; GS V (90–120 DAP): Maturation.

temperature, day-night temperature delta, rainfall, radiation, cloud cover, sunshine duration, and frost risk) will change. Each month, the weights of each criterion and agroclimatic factor (average temperature, daytime t emperature, nighttime temperature, day-night temperature delta, rainfall, radiation, cloud cover, sunshine duration, and frost risk) will change. The scoring of each non-agroclimatic factor criterion was derived using the data range (quartile) from secondary data and literature studies. Each criterion was weighted according to its value or influence, as judged by PT ABCD's internal judgment.

The weight for agroclimatic factors is 0.8, which consisted of average temperature 0.25, daytime temperature 0.1, nighttime temperature 0.15, day-night temperature delta 0.15, rainfall 0.05, radiation 0.02, cloud cover 0.02, sunshine duration 0.02, frost risk 0.02; and the weight for non-agroclimatic factors was 0.2, which consists of land altitude 0.02, harvested area in hectares 0.05, potato production in tonnage 0.03, productivity 0.02, travel time to factory location 0.01, level of disease attack 0.02, level of pest attack 0.02, type of irrigation 0.02, production cost 0.01, competition with similar industries 0.01, and farmers' cultivation experience 0.01.

Monthly agro-climatic and non-agro-climatic data for each subdistrict were compared to standard ratings, with values assigned as 1 (unsuitable), 3 (suitable), or 9 (very appropriate). The weighting of each criterion is shown in Table 2. After calculating the weights, the next step was to determine each alternative's ranking and preference value (Table 3). The next step was to normalize each alternative vector value, calculate the alternative values, and rank them (Table 4).

CONCLUSION

The purpose of this study was to determine the most ideal potato growing regions at the subdistrict level, considering both agroclimatic and non-agroclimatic parameters. The top ten subdistricts for industrial potato cultivation were identified: Batur (Banjarnegara, Central Java), Tosari (Pasuruan, East Java), Pasir Wangi (Garut, West Java), Cikajang (Garut, West Java), Sirampog (Brebes, Central Java), Pejawaran (Banjarnegara, Central Java), Bawang (Batang, Central Java), Kayu Aro (Kerinci, Jambi), Pangalengan (Bandung, West Java), and Kejajar (Wonosobo, Central Java).

Table 2 Weighting and scores of criteria

Criteria		Weighting score	Standard score for criteria			Measurement Unit
			Highly suitable (Score 9)	Suitable (Score 3)	Not suitable (Score 1)	
Average day/night temperature	Jan	0.0144	15–18	18–25	<=5 & >25	°C
	Feb	0.0048	15–18	18–25	<=5 & >25	°C
	Mar	0.0048	15–18	18–25	<=5 & >25	°C
	Apr	0.0144	15–18	18–25	<=5 & >25	°C
	May	0.0144	15–18	18–25	<=5 & >25	°C
	Jun	0.0433	15–18	18–25	<=5 & >25	°C
	Jul	0.0433	15–18	18–25	<=5 & >25	°C
	Aug	0.0048	15–18	18–25	<=5 & >25	°C
	Sep	0.0048	15–18	18–25	<=5 & >25	°C
	Oct	0.0144	15–18	18–25	<=5 & >25	°C
	Nov	0.0433	15–18	18–25	<=5 & >25	°C
	Dec	0.0433	15–18	18–25	<=5 & >25	°C
Day temperature	Jan	0.0058	15–18	18–25	<=5 & >30	°C
	Feb	0.0019	15–18	18–25	<=5 & >30	°C
	Mar	0.0019	15–18	18–25	<=5 & >30	°C
	Apr	0.0058	15–18	18–25	<=5 & >30	°C
	May	0.0058	15–18	18–25	<=5 & >30	°C
	Jun	0.0173	15–18	18–25	<=5 & >30	°C
	Jul	0.0173	15–18	18–25	<=5 & >30	°C
	Aug	0.0019	15–18	18–25	<=5 & >30	°C
	Sep	0.0019	15–18	18–25	<=5 & >30	°C
	Oct	0.0058	15–18	18–25	<=5 & >30	°C
	Nov	0.0173	15–18	18–25	<=5 & >30	°C
	Dec	0.0173	15–18	18–25	<=5 & >30	°C
Night Temperature	Jan	0.0087	15–18	18–25	<=5 & >25	°C
	Feb	0.0029	15–18	18–25	<=5 & >25	°C
	Mar	0.0029	15–18	18–25	<=5 & >25	°C
	Apr	0.0087	15–18	18–25	<=5 & >25	°C
	May	0.0087	15–18	18–25	<=5 & >25	°C
	Jun	0.0260	15–18	18–25	<=5 & >25	°C
	Jul	0.0260	15–18	18–25	<=5 & >25	°C
	Aug	0.0029	15–18	18–25	<=5 & >25	°C
	Sep	0.0029	15–18	18–25	<=5 & >25	°C
	Oct	0.0087	15–18	18–25	<=5 & >25	°C
	Nov	0.0260	15–18	18–25	<=5 & >25	°C
	Dec	0.0260	15–18	18–25	<=5 & >25	°C

Table 2 Weighting and scores of criteria

Criteria		Weighting score	Standard score for criteria			Measurement Unit
			Highly suitable (Score 9)	Suitable (Score 3)	Not suitable (Score 1)	
Day-night temperature delta	Jan	0.0087	>12	8–12	<= 8	°C
	Feb	0.0029	>12	8–12	<= 8	°C
	Mar	0.0029	>12	8–12	<= 8	°C
	Apr	0.0087	>12	8–12	<= 8	°C
	May	0.0087	>12	8–12	<= 8	°C
	Jun	0.0260	>12	8–12	<= 8	°C
	Jul	0.0260	>12	8–12	<= 8	°C
	Aug	0.0029	>12	8–12	<= 8	°C
	Sep	0.0029	>12	8–12	<= 8	°C
	Oct	0.0087	>12	8–12	<= 8	°C
	Nov	0.0260	>12	8–12	<= 8	°C
	Dec	0.0260	>12	8–12	<= 8	°C
Rainfall	Jan	0.0010	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Feb	0.0010	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Mar	0.0087	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Apr	0.0087	50–100	20–50 & 100–150	<=20 & >150	mm/day
	May	0.0029	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Jun	0.0029	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Jul	0.0010	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Aug	0.0010	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Sep	0.0087	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Oct	0.0087	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Nov	0.0029	50–100	20–50 & 100–150	<=20 & >150	mm/day
	Dec	0.0029	50–100	20–50 & 100–150	<=20 & >150	mm/day
Radiation	Jan	0.0004	>300	209.3–300	<=209.3	w/m²
	Feb	0.0004	>300	209.3–300	<=209.3	w/m²
	Mar	0.0035	>300	209.3–300	<=209.3	w/m²
	Apr	0.0035	>300	209.3–300	<=209.3	w/m²
	May	0.0012	>300	209.3–300	<=209.3	w/m²
	Jun	0.0012	>300	209.3–300	<=209.3	w/m²
	Jul	0.0004	>300	209.3–300	<=209.3	w/m²
	Aug	0.0004	>300	209.3–300	<=209.3	w/m²
	Sep	0.0035	>300	209.3–300	<=209.3	w/m²
	Oct	0.0035	>300	209.3–300	<=209.3	w/m²
	Nov	0.0012	>300	209.3–300	<=209.3	w/m²
	Dec	0.0012	>300	209.3–300	<=209.3	w/m²
Cloud cover	Jan	0.0012	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Feb	0.0004	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Mar	0.0004	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Apr	0.0012	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	May	0.0012	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Jun	0.0035	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Jul	0.0035	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Aug	0.0004	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Sep	0.0004	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Oct	0.0012	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Nov	0.0035	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%
	Dec	0.0035	<51.5 (<quartile 1)	51.5–67.9 (quartile 1–3)	>67.9 (>quartile 3)	%

The Weighted Product (WP) technique efficiently explains the process of identifying optimal potato growing locations at the subdistrict level by using both agroclimatic and non-agroclimatic variables. The

Table 2 Weighting and scores of criteria

Criteria		Weighting score	Standard score for criteria			Measurement Unit
			Highly suitable (Score 9)	Suitable (Score 3)	Not suitable (Score 1)	
Sunshine duration	Jan	0.0004	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 *(>quartile 3)*	Hour
	Feb	0.0004	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Mar	0.0035	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Apr	0.0035	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	May	0.0012	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Jun	0.0012	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Jul	0.0004	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Aug	0.0004	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Sep	0.0035	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Oct	0.0035	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Nov	0.0012	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
	Dec	0.0012	<11.8 (<quartile 1)	11.8–12.2 (quartile 1–3)	>12.2 (>quartile 3)	Hour
Frost risk	Jan	0.0005	0	<3	>5	# of days per month
	Feb	0.0005	0	<3	>5	# of days per month
	Mar	0.0005	0	<3	>5	# of days per month
	Apr	0.0015	0	<3	>5	# of days per month
	May	0.0045	0	<3	>5	# of days per month
	Jun	0.0045	0	<3	>5	# of days per month
	Jul	0.0045	0	<3	>5	# of days per month
	Aug	0.0015	0	<3	>5	# of days per month
	Sep	0.0005	0	<3	>5	# of days per month
	Oct	0.0005	0	<3	>5	# of days per month
	Nov	0.0005	0	<3	>5	# of days per month
	Dec	0.0005	0	<3	>5	# of days per month
Altitude	0.0200	1500	1000–1500	<1000	meter	
Harvested area	0.0500	>1,344 (<quartile 3)	185.3–1,344 (quartile 1– quartile 3)	<185.3 (<quartile 1)	hectare (ha)	
Production						
Productivity	0.0300	>29,374.5 (<quartile 3)	3429.8–29,374.5 (quartile 1– quartile 3)	<3429.8 (<quartile 1)	tonnage (T)	
Travel time to the factory location	0.0200	>23 (>quartile 3)	17.3–23 (quartile 1– quartile 3)	<17.3 (<quartile 1)	tonnage per hectare	
Disease infestation level	0.0100	<12	12–48	>48	hour	
Pest infestation level	0.0200	1x	2x	4x	# of frequency in last 4 planting seasons	
Irrigation type	0.0200	1x	2x	4x	# of frequency in last 4 planting seasons	
Production cost (including logistic cost)	0.0200	Drip irrigation	Sprinkle & water pump	Rainfed and manual irrigation		
	0.0100	<100	100–120	>120	IDR million/ha	
Sourcing competition with another player	0.0100	0–1	1–3	>3	number of competitor	
	0.0100	>10	5–10	<5	year	
Farmer experience in potato cultivation						

study's findings can be used as a decision-making tool for the potato chips sector to determine ideal

Table 3 Ranking calculation and preference values

Alternative	Province	District	Subdistrict	Score of average day/night Temperature	Day temperature score	Night temperature score	Day–night temperature delta score	Rainfall score	Sunshine duration score	Cloud cover score	Radiation score	Altitude score	Frost risk score	Harvested area score	Production score	Productivity score	Travel time score	Disease attack level score	Pest attack level score	Irrigation type score	Production cost score	Competition score	Farmer experience score	Alternative value	Preference value
S1	Bengkulu	Rejang Lebong	Curup	1.3	1.1	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.1	3.0	3.0	9.0	3.0	1.0	3.0	1.0	3.0	9.0	1.0	1.38	0.02
S2	Bengkulu	Kepahiang	Kebawetan	1.3	1.1	1.4	1.1	1.0	1.0	1.0	1.0	9.0	1.1	1.0	1.0	1.0	3.0	1.0	3.0	1.0	3.0	9.0	1.0	1.29	0.02
S3	Central Java	Banjarnegara	Pejawaran	1.3	1.1	1.3	1.2	1.0	1.0	1.0	1.0	3.0	1.1	9.0	9.0	3.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.55	0.02
S4	Central Java	Banjarnegara	Batur	1.6	1.1	1.2	1.2	1.0	1.0	1.0	1.0	9.0	1.1	9.0	9.0	3.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.64	0.02
S5	Central Java	Batang	Bawang	1.3	1.1	1.3	1.2	1.0	1.0	1.0	1.0	9.0	1.1	3.0	3.0	3.0	9.0	3.0	3.0	3.0	3.0	3.0	9.0	1.54	0.02
S6	Central Java	Brebes	Sirampog	1.3	1.1	1.3	1.2	1.0	1.0	1.0	1.0	3.0	1.1	9.0	9.0	3.0	9.0	1.0	1.0	3.0	3.0	3.0	9.0	1.57	0.02
S7	Central Java	Brebes	Paguyangan	1.3	1.1	1.2	1.1	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	1.0	9.0	1.0	1.0	3.0	3.0	3.0	9.0	1.39	0.02
S8	Central Java	Pemalang	Pulo Sari	1.3	1.1	1.4	1.3	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	3.0	9.0	3.0	3.0	3.0	3.0	1.0	9.0	1.36	0.02
S9	Central Java	Wonosobo	Kejajar	1.6	1.1	1.2	1.2	1.0	1.0	1.0	1.0	1.0	1.1	9.0	9.0	1.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.53	0.02
S10	East Java	Malang	Ngantang	1.3	1.1	1.3	1.1	1.0	1.0	1.0	1.0	9.0	1.1	1.0	1.0	1.0	3.0	3.0	3.0	3.0	1.0	1.0	9.0	1.33	0.02
S11	East Java	Malang	Poncokusumo	1.3	1.1	1.3	1.2	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	1.0	3.0	1.0	1.0	3.0	1.0	1.0	9.0	1.37	0.02
S12	East Java	Malang	Pujon	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	9.0	3.0	1.0	1.0	3.0	1.0	1.0	9.0	1.29	0.02
S13	East Java	Pasuruan	Tosari	1.6	1.1	1.2	1.2	1.0	1.0	1.0	1.0	3.0	1.1	9.0	9.0	9.0	3.0	1.0	1.0	3.0	1.0	1.0	9.0	1.63	0.02
S14	East Java	Pasuruan	Tutur	1.3	1.1	1.4	1.1	1.0	1.0	1.0	1.0	3.0	1.1	3.0	9.0	9.0	3.0	1.0	1.0	3.0	1.0	1.0	9.0	1.48	0.02
S15	East Java	Pasuruan	Puspo	1.3	1.1	1.3	1.1	1.0	1.0	1.0	1.0	1.0	1.1	3.0	9.0	9.0	3.0	1.0	1.0	3.0	1.0	1.0	9.0	1.44	0.02
S16	East Java	Probolinggo	Sukapura	1.6	1.1	1.2	1.2	1.0	1.0	1.0	1.0	9.0	1.1	3.0	3.0	1.0	3.0	1.0	1.0	3.0	1.0	1.0	9.0	1.45	0.02
S17	East Java	Probolinggo	Sumber	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	3.0	1.1	9.0	3.0	1.0	3.0	1.0	1.0	3.0	1.0	1.0	9.0	1.46	0.02
S18	Jambi	Kerinci	Kayu Aro	1.3	1.1	1.2	1.2	1.1	1.0	1.0	1.0	9.0	1.1	9.0	9.0	3.0	1.0	1.0	1.0	3.0	3.0	3.0	3.0	1.54	0.02
S19	Jambi	Merangin	Jangkat	1.4	1.1	1.2	1.1	1.1	1.0	1.0	1.0	3.0	1.1	3.0	3.0	3.0	1.0	1.0	3.0	1.0	3.0	9.0	3.0	1.41	0.02
S20	North Sulawesi	Bolaang mongondow timur	Passi timur	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	3.0	1.0	1.0	3.0	1.0	3.0	9.0	1.0	1.41	0.02
S21	North Sulawesi	Minahasa selatan	Modoinding	1.3	1.1	1.4	1.1	1.0	1.0	1.0	1.0	3.0	1.1	9.0	9.0	3.0	1.0	1.0	3.0	1.0	3.0	9.0	1.0	1.52	0.02
S22	North Sumatera	Humbang Hansudutan	Pollung	1.3	1.1	1.2	1.2	1.1	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	1.0	1.0	3.0	1.0	3.0	3.0	1.0	1.25	0.02
S23	North Sumatera	Humbang Hansudutan	Dolok sanggul	1.3	1.1	1.2	1.2	1.1	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	1.0	1.0	3.0	1.0	3.0	9.0	1.0	1.27	0.02
S24	North Sumatera	Humbang Hansudutan	Lintong Nihuta	1.3	1.1	1.4	1.2	1.1	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	1.0	1.0	3.0	1.0	3.0	9.0	1.0	1.30	0.02
S25	North Sumatera	Karo	Naman teran	1.3	1.1	1.3	1.3	1.1	1.0	1.0	1.0	3.0	1.1	3.0	3.0	3.0	1.0	1.0	3.0	1.0	1.0	3.0	3.0	1.40	0.02
S26	North Sumatera	Karo	Simpang Empat	1.3	1.1	1.3	1.3	1.1	1.0	1.0	1.0	3.0	1.1	3.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	3.0	1.30	0.02
S27	North Sumatera	Karo	Merdeka	1.3	1.1	1.2	1.2	1.1	1.0	1.0	1.0	3.0	1.1	3.0	3.0	3.0	1.0	1.0	1.0	1.0	1.0	3.0	3.0	1.33	0.02
S28	North Sumatera	Karo	Merek	1.3	1.1	1.2	1.3	1.1	1.0	1.0	1.0	3.0	1.1	3.0	3.0	1.0	1.0	1.0	1.0	1.0	1.0	3.0	3.0	1.32	0.02
S29	North Sumatera	Simalungun	Purba	1.3	1.1	1.2	1.3	1.1	1.0	1.0	1.0	3.0	1.1	9.0	3.0	1.0	1.0	1.0	3.0	1.0	3.0	3.0	3.0	1.44	0.02
S30	North Sumatera	Simalungun	Silimakuta	1.3	1.1	1.4	1.1	1.1	1.0	1.0	1.0	3.0	1.1	3.0	3.0	1.0	1.0	1.0	3.0	1.0	3.0	3.0	3.0	1.36	0.02
S31	North Sumatera	Simalungun	Pamatang Silimahuta	1.3	1.1	1.4	1.1	1.1	1.0	1.0	1.0	3.0	1.1	3.0	3.0	1.0	1.0	1.0	3.0	1.0	3.0	3.0	3.0	1.37	0.02
S32	South Sulawesi	Bantaeng	Uluere	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	3.0	1.0	1.0	3.0	1.0	3.0	9.0	1.0	1.42	0.02
S33	South Sulawesi	Gowa	Tombolo pao	1.3	1.1	1.4	1.1	1.0	1.0	1.0	1.0	1.0	1.1	9.0	9.0	3.0	1.0	1.0	3.0	1.0	3.0	9.0	1.0	1.49	0.02
S34	South Sumatera	Muara Enim	Semendo darat	1.3	1.1	1.3	1.2	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	3.0	3.0	1.0	3.0	1.0	3.0	9.0	1.0	1.40	0.02
S35	West Java	Garut	Cigedug	1.4	1.1	1.2	1.2	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	9.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.44	0.02
S36	West Java	Garut	Pasir Wangi	1.3	1.1	1.4	1.3	1.0	1.0	1.0	1.0	3.0	1.1	9.0	9.0	9.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.60	0.02
S37	West Java	Garut	Cisurupan	1.3	1.1	1.2	1.2	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	9.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.44	0.02
S38	West Java	Garut	Cikajang	1.3	1.1	1.2	1.3	1.0	1.0	1.0	1.0	3.0	1.1	9.0	9.0	9.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.58	0.02
S39	West Java	Garut	Banjarwangi	1.3	1.1	1.3	1.1	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	9.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.43	0.02
S40	West Java	Garut	Cilawu	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	3.0	1.1	1.0	3.0	9.0	9.0	3.0	3.0	3.0	1.0	1.0	9.0	1.44	0.02
S41	West Java	Garut	sucinaraja	1.2	1.1	1.3	1.3	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	9.0	9.0	3.0	3.0	3.0	1.0	1.0	9.0	1.48	0.02
S42	West Java	Kab Bandung	Pangalengan	1.3	1.1	1.2	1.3	1.0	1.0	1.0	1.0	3.0	1.1	9.0	9.0	3.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.54	0.02
S43	West Java	Kab Bandung	Kertasari	1.5	1.1	1.2	1.3	1.0	1.0	1.0	1.0	9.0	1.1	3.0	3.0	3.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.48	0.02
S44	West Java	Kab Bandung	Paseh	1.2	1.1	1.3	1.3	1.0	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.26	0.02
S45	West Java	Kab Bandung	Pasir jambu	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.31	0.02
S46	West Java	Kab Bandung	Cimenyan	1.3	1.1	1.4	1.3	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	3.0	9.0	1.0	1.0	3.0	1.0	1.0	9.0	1.44	0.02
S47	West Java	Majalengka	Banjaran	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	9.0	1.0	1.0	3.0	3.0	3.0	9.0	1.28	0.02
S48	West Java	Majalengka	Argapura	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	9.0	1.0	1.0	3.0	3.0	3.0	3.0	1.32	0.02
S49	West Java	Majalengka	Talaga	1.2	1.1	1.2	1.2	1.0	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	9.0	1.0	1.0	3.0	3.0	3.0	3.0	1.27	0.02
S50	West Java	Majalengka	Cikijing	1.3	1.1	1.3	1.2	1.0	1.0	1.0	1.0	3.0	1.1	1.0	1.0	3.0	9.0	1.0	1.0	3.0	3.0	3.0	3.0	1.31	0.02
S51	West Nusa Tenggara	Lombok Timur	Sembalun	1.3	1.1	1.4	1.2	1.0	1.0	1.0	1.0	3.0	1.1	3.0	3.0	1.0	1.0	1.0	3.0	3.0	1.0	1.0	1.0	1.36	0.02
S52	West Sumatera	Solok	Lembah gumanti	1.3	1.1	1.2	1.2	1.1	1.0	1.0	1.0	3.0	1.1	3.0	3.0	9.0	1.0	1.0	3.0	3.0	3.0	3.0	3.0	1.44	0.02
S53	West Sumatera	Solok	Danau Kembar	1.4	1.1	1.2	1.1	1.1	1.0	1.0	1.0	9.0	1.1	3.0	3.0	3.0	1.0	1.0	3.0	3.0	3.0	3.0	3.0	1.46	0.02

Table 4 Alternative values, preference values, and ranks

Alternative	Subdistrict	Alternative value	Vector	Preference value	Rank
S4	Batur	1.64	V4	0.022	1
S13	Tosari	1.63	V13	0.022	2
S36	Pasir Wangi	1.60	V36	0.021	3
S38	Cikajang	1.58	V38	0.021	4
S6	Sirampog	1.57	V6	0.021	5
S3	Pejawaran	1.55	V3	0.021	6
S5	Bawang	1.54	V5	0.021	7
S18	Kayu Aro	1.54	V18	0.020	8
S42	Pangalengan	1.54	V42	0.020	9
S9	Kejajar	1.53	V9	0.020	10
S21	Modoinding	1.52	V21	0.020	11
S33	Tombolo pao	1.49	V33	0.020	12
S14	Tutur	1.48	V14	0.020	13
S41	sucinaraja	1.48	V41	0.020	14
S43	Kertasari	1.48	V43	0.020	15
S17	Sumber	1.46	V17	0.019	16
S53	Danau Kembar	1.46	V53	0.019	17
S16	Sukapura	1.45	V16	0.019	18
S37	Cisurupan	1.44	V37	0.019	19
S46	Cimenyan	1.44	V46	0.019	20
S40	Cilawu	1.44	V40	0.019	21
S35	Cigedug	1.44	V35	0.019	22
S52	Lembah gumanti	1.44	V52	0.019	23
S15	Puspo	1.44	V15	0.019	24
S29	Purba	1.44	V29	0.019	25
S39	Banjarwangi	1.43	V39	0.019	26
S32	Uluere	1.42	V32	0.019	27
S20	Passi timur	1.41	V20	0.019	28
S19	Jangkat	1.41	V19	0.019	29
S34	Semendo darat	1.40	V34	0.019	30
S25	Naman teran	1.40	V25	0.019	31
S7	Paguyangan	1.39	V7	0.018	32
S1	Curup	1.38	V1	0.018	33
S11	Poncokusumo	1.37	V11	0.018	34
S31	Pamatang Silimahuta	1.37	V31	0.018	35
S51	Sembalun	1.36	V51	0.018	36
S8	Pulo Sari	1.36	V8	0.018	37
S30	Silimakuta	1.36	V30	0.018	38
S10	Ngantang	1.33	V10	0.018	39
S27	Merdeka	1.33	V27	0.018	40
S48	Argapura	1.32	V48	0.018	41
S28	Merek	1.32	V28	0.018	42
S50	Cikijing	1.31	V50	0.017	43
S45	Pasir jambu	1.31	V45	0.017	44
S26	Simpang Empat	1.30	V26	0.017	45
S24	Lintong Nihuta	1.30	V24	0.017	46
S2	Kebawetan	1.29	V2	0.017	47
S12	Pujon	1.29	V12	0.017	48
S47	Banjaran	1.28	V47	0.017	49
S23	Dolok sanggul	1.27	V23	0.017	50
S49	Talaga	1.27	V49	0.017	51
S44	Paseh	1.26	V44	0.017	52
S22	Pollung	1.25	V22	0.017	53

production locations that meet both climatic and non-climatic criteria.

Future research could compare the WP method to other ways, such as Simple Additive Weighting (SAW) and Matching method. Incorporating soil condition and and Matching method. Incorporating soil condition variables, such as groundwater level, soil temperature, soil acidity, and topography at the village or farm plot level may also improve the robustness of site selection analysis.

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