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# Marketing priorities for hydroponic lettuce in sustainable urban agrifood systems: evidence from modern retail in Tarakan

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**ABSTRACT**

Hydroponic lettuce is part of an urban agrifood system in which production continuity must be matched by economically viable demand, retail access, and effective market coordination. This study evaluated the market-side priorities for hydroponic lettuce at Super Sayur Fresh 3 in Tarakan using survey responses from 50 consumers. Fifteen Likert-scale items measured product, price, place, promotion, and purchase decisions. The analysis combined ordinary least squares, HC3 robust standard errors, paired bootstrap resampling with 10,000 replications, general dominance analysis, and importance-performance mapping. The model was significant ($F = 2.969$; $p = 0.029$; $R^2 = 0.209$). Promotion was the only significant predictor ($B = 0.347$; HC3 $p = 0.019$; bootstrap 95% CI = 0.075-0.623) and accounted for 69.87% of explained variance. Product accounted for 23.88%, price for 5.67%, and place for 0.58%. Promotion combined high importance with lower performance than product, particularly for advertising attractiveness. The findings identify promotion as the principal market-coordination priority for local hydroponic retail. Their sustainability implication is limited to the economic-market dimension of urban agrifood development; the study does not assess environmental performance of hydroponic production.

## INTRODUCTION

Sustainable urban agrifood systems depend on more than production technology. Their functioning connects production with distribution, retail access, consumer demand, and the economic viability of local food enterprises. Literature on urban agriculture shows that it can contribute to food-system sustainability and resilience, but its contribution is context dependent and cannot substitute for the wider food system [1]. Hydroponic production likewise should not be assumed to be environmentally superior by definition: recent life-cycle evidence for lettuce identifies trade-offs among land use, water use, energy demand, and greenhouse-gas emissions, with outcomes strongly influenced by production configuration and energy sources [2]. Accordingly, this study uses sustainability in a bounded sense. It examines the market-side and economic continuity of local urban horticulture rather than claiming to measure the environmental sustainability of hydroponic production.

Urban fresh-food retail has expanded as consumers have become more attentive to cleanliness, shopping convenience, and perceived health benefits. Hydroponic lettuce (*Lactuca sativa L.*) has gained market space because it is commonly perceived as clean, uniform, and convenient for fresh consumption. In cities with limited land, hydroponic systems allow water and nutrients to be managed in a controlled manner, although crop quality remains dependent on nutrient formulation and system management [3,4]. Experience in Tarakan indicates that this technology can support urban production [5], but continuity of output depends on water circulation, nutrient supply, and energy availability [6]. Its economic potential is realized when production is connected to a market with demand that can be sustained [7].

Consumers do not choose hydroponic lettuce solely to satisfy a basic food need. They evaluate freshness, packaging, cleanliness, price, store access, and the reasons the product may justify a premium over conventional alternatives. The marketing mix provides a practical framework for managing those judgments. Product represents quality; price reflects sacrifice and perceived fairness; place concerns access; and promotion translates product benefits into market information [8]. Purchase decisions are also shaped by experience, habits, preferences, perceived risk, and information available before the transaction [9]. The four elements of the marketing mix should therefore be considered as an integrated configuration, although their contributions need not be equal in every retail setting.

Empirical evidence concerning hydroponic vegetables is mixed. A study of the 7P marketing mix for hydroponic lettuce found that the marketing elements were jointly associated with purchase decisions, but their strengths differed [10]. Other studies show that place or price is not always decisive when consumers are already familiar with the retail channel or value the product benefits more highly than the price difference [11,12]. Social-media promotion can also influence agribusiness shopping behavior through exposure to product information [13]. These variations indicate that the effectiveness of the marketing mix is context dependent and should be interpreted in relation to market structure, consumer characteristics, sales format, and product differentiation.

In Tarakan, studies of red chili, tomato, and watermelon have reported different patterns of marketing-mix effects across commodities and selling locations [14-16]. However, those studies

focused on conventional horticultural products and did not explain the purchase of hydroponic lettuce in modern retail. Hydroponic lettuce has distinctive attributes related to cultivation technology, freshness, packaging, and benefit information, so its marketing communication may differ from that of staple commodities sold in traditional markets. This gap supports an analysis that tests not only the statistical significance of the four marketing elements but also the stability of their estimates and their order of managerial priority.

Super Sayur Fresh 3 is a local modern vegetable retailer in Tarakan. Store information indicates sales of approximately 600 packages of lettuce per month. Demand is relatively stable, but availability follows harvest cycles, hydroponic lettuce is priced above conventional lettuce, parking space is limited, and promotional materials do not always communicate benefits clearly. Management must decide where to allocate attention because improvements in quality, price, access, and promotion all require resources but may not generate equal gains in explanatory power. Some attributes may operate as prerequisites: consumers expect fresh products, visible prices, and reachable stores. Others may operate as levers that make the product's value easier to recognize. Distinguishing prerequisites from strategic levers prevents a statistically nonsignificant element from being treated as operationally unimportant and prevents promotion from being strengthened at the expense of basic product quality.

Conventional regression analysis commonly emphasizes p-values and standardized or unstandardized coefficients. This is useful, but it does not fully answer a managerial prioritization problem. In a small sample, standard errors can be sensitive to heteroskedasticity and influential observations. HC3 covariance estimation was developed to improve finite-sample inference under such conditions [17], whereas bootstrap resampling constructs an empirical distribution of coefficients [18]. Moreover, regression coefficients do not directly partition $R^2$ among correlated predictors. A variable can therefore be statistically significant without being the largest contributor to explained variance, and the reverse can also occur.

Dominance analysis estimates the incremental $R^2$ of each predictor across all subset models [19]. Its output shows the proportion of explanatory power associated with product, price, place, and promotion. Relative importance can then be combined with current performance in a priority map, adapting the logic of importance-performance analysis [20]. Accordingly, this study tested the robustness of marketing-mix effects using ordinary least squares with HC3 standard errors and bootstrap intervals, decomposed relative contributions through dominance analysis, and mapped importance-performance gaps. Its novelty lies in transforming indicator-level survey data into a strategic diagnosis based on estimate stability, explained variance, and consumer-reported performance. The analysis is intended to provide an operational basis for resource allocation in a modern vegetable retailer without converting observational associations into causal claims. The study therefore asks not only which marketing element is statistically important, but how retail priorities can support market continuity within a sustainable urban agrifood system. This positions the analysis within sustainable-development research on the economic-market node of local food systems while leaving environmental and social sustainability outcomes outside the empirical model.

# MATERIALS AND METHODS

## Research Site, Design, and Data Source

The study was conducted at Super Sayur Fresh 3, Jalan R.E. Martadinata, Pamusian Urban Village, Central Tarakan District, Tarakan City, from November 2025 to February 2026. The original design was a quantitative survey of consumers who had purchased or were purchasing hydroponic lettuce. Because a complete sampling frame was unavailable, respondents were selected through accidental sampling at the point of purchase [21]. The sample comprised 50 consumers, including 39 women and 11 men. The article used a 50-respondent by 15-item data matrix from the appendix to Nurul Anisa's undergraduate research. The matrix was transcribed and verified against the reported coefficients, $R^2$, F statistic, and SPSS output. Both authors approved the use of the data and the authorship order.

## Instrument and Measurements

The instrument contained three indicators for each construct (Table 1). Product was measured through packaging protection, product quality, and brand-name suitability; price through affordability and clarity, benefit-price fit, and competitiveness; place through access, parking and security, and store cleanliness; promotion through advertising attractiveness, discounts, and promotional information; and purchase decisions through product need, repeat purchase, and perceived value. Responses used a five-point Likert scale, and each construct score was calculated as the unweighted sum of its three items. Item validity was assessed using item-total correlations and reliability using Cronbach's alpha. All indicators had item-total correlations of 0.764-0.916 and alpha values of 0.703-0.843.

**Table 1. Variables and indicators used in the study**

| Variable | Code | Indicators |
|---|---|---|
| **Product** | $X_1$ | Packaging protection; product quality; brand-name suitability |
| **Price** | $X_2$ | Affordability and clarity; benefit-price fit; price competitiveness |
| **Place** | $X_3$ | Access; parking and security; store cleanliness |
| **Promotion** | $X_4$ | Advertising attractiveness; discounts; promotional information |
| **Purchase decision** | Y | Product need; repeat purchase; perceived value |

*Source: Research instrument, 2026.*

## Analytical Procedures

Analysis proceeded in four stages. First, ordinary least squares (OLS) replicated the model $Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon$. Model assumptions were evaluated using the Kolmogorov-Smirnov test, tolerance and variance inflation factors, and the Glejser test [22]. Second, inference was recalculated with the HC3 heteroskedasticity-consistent covariance matrix. HC3 was used to correct OLS standard errors and should not be confused with robust regression based on M-estimation. Third, uncertainty was evaluated by paired bootstrap resampling with 10,000 replications and 95% percentile intervals. A coefficient was considered stable when its interval did not cross zero and its direction agreed with the HC3 result.

Fourth, the general dominance weight was calculated as the mean incremental $R^2$ of a predictor across all possible subset models [19]. The weights summed to the full-model $R^2$ and were expressed as percentages. Construct performance was transformed to a 0-100 index using ((mean - 1) / 4) × 100. The importance-performance map adapted the logic of importance-performance analysis [20]. The performance divider was the mean index across the four constructs, whereas the importance divider was 25% because the model contained four predictors. Analyses used seed 20260728 and were run in Python 3.13.5 with pandas 2.2.3, NumPy 2.3.5, SciPy 1.17.0, and statsmodels 0.14.6.

Before estimation, the dataset was audited to confirm 50 rows, 15 indicators, scores ranging from 1 to 5, and no missing values. Replication was accepted when the OLS coefficients, $R^2$, adjusted $R^2$, F statistic, and p-value matched the SPSS output after rounding. Decisions used $\alpha = 0.05$, but interpretation also considered confidence intervals, coefficient direction, dominance weights, and performance. Paired bootstrap sampling preserved the relationships among variables within each respondent. Dominance weights were checked to ensure that their sum equaled the full-model $R^2$ to four

decimal places. All indices and indicator means were calculated from the same verified data matrix.

# RESULTS

## Respondent Profile and Measurement Quality

Women represented 78% of the sample, and respondents aged 17-29 years represented 44%. Educational attainment was concentrated at the senior-high-school and bachelor levels, each accounting for 44%. The largest monthly income category was IDR 500,000-2,000,000 (36%), followed by IDR 2,000,000-5,000,000 (34%). The consumer base at the study site was therefore not limited to high-income buyers; it included young consumers and households with varied purchasing capacity.

All indicators met the validity and reliability criteria. Cronbach's alpha was 0.703 for product, 0.830 for price, 0.813 for place, 0.809 for promotion, and 0.843 for purchase decisions. Model residuals were normally distributed ($p = 0.200$); tolerance values of 0.710-0.875 and variance inflation factors of 1.143-1.409 indicated no multicollinearity; and Glejser-test p-values ranged from 0.403 to 0.968. These diagnostics supported OLS estimation, while HC3 and bootstrap procedures provided additional protection against small-sample inferential sensitivity.

The OLS model exactly replicated the original results: $R = 0.457$, $R^2 = 0.209$, adjusted $R^2 = 0.138$, $F = 2.969$, and $p = 0.029$. The unstandardized coefficients were 0.220 for product, -0.022 for price, -0.033 for place, and 0.347 for promotion. Promotion was the only predictor that was individually significant under OLS. Because the model explained 20.9% of the variation in purchase decisions, the four marketing elements represented only one part of the consumer decision process.

## Robustness of the Regression Estimates

The HC3 correction did not change coefficient directions (Table 2). Promotion remained positive and significant ($B = 0.347$; $p = 0.019$), with a 95% confidence interval of 0.059-0.636. The 10,000-replication bootstrap interval was 0.075-0.623 and also remained entirely above zero. Product retained a positive coefficient, but both its HC3 and bootstrap intervals crossed zero. Price and place had very small coefficients, with intervals spanning negative and positive values.

**Table 2. OLS, HC3, and bootstrap estimates**

| Variable | B | OLS p | HC3 SE | HC3 p | Bootstrap 95% CI |
|---|---|---|---|---|---|
| **Constant** | 6.393 | 0.016 | 2.612 | 0.018 | 1.103-10.878 |
| **Product** | 0.220 | 0.223 | 0.166 | 0.192 | -0.102-0.546 |
| **Price** | -0.022 | 0.870 | 0.112 | 0.846 | -0.246-0.190 |
| **Place** | -0.033 | 0.788 | 0.111 | 0.771 | -0.219-0.204 |
| **Promotion** | 0.347 | 0.012 | 0.143 | 0.019 | 0.075-0.623 |

*Note: Bootstrap intervals are based on 10,000 percentile replications. Source: Primary data processed, 2026.*

Differences between OLS and HC3 p-values were modest, and the promotion effect remained stable under both inferential procedures. In contrast, the nonsignificant product coefficient reflected its unique partial effect after the other predictors were controlled; it did not by itself measure the product construct's share of total explained variance.

## Dominance and Strategic Priority

Dominance analysis partitioned the model's explanatory power across all predictor combinations (Table 3). Promotion had a dominance weight of 0.1459, equivalent to 69.87% of the full-model $R^2$. Product had a weight of 0.0499 or 23.88%, price accounted for 5.67%, and place for 0.58%. Thus, product still contributed almost one-quarter of the explained variance despite being nonsignificant in the full-model partial test.

**Table 3. Dominance and performance of marketing-mix elements**

| Variable | Dominance weight | Contribution (%) | Mean | Performance index | Position |
|---|---|---|---|---|---|
| **Product** | 0.0499 | 23.88 | 4.35 | 83.67 | Maintain |
| **Price** | 0.0118 | 5.67 | 4.03 | 75.83 | Support |
| **Place** | 0.0012 | 0.58 | 3.79 | 69.67 | Selective improvement |
| **Promotion** | 0.1459 | 69.87 | 3.87 | 71.83 | Primary priority |

*Note: Dominance weights sum to the full-model $R^2$ (0.2088). Performance index range: 0-100. Source: Primary data processed, 2026.*

Performance indices showed a different ordering. Product recorded the highest index (83.67), followed by price (75.83), promotion (71.83), and place (69.67). Promotion therefore combined the highest relative importance with performance below the construct mean, identifying it as the primary area for improvement. Product represented a high-performing strength to be maintained, whereas price and place had lower relative importance and functioned as supporting operational conditions.

At the indicator level, store access had a mean of 3.70, advertising attractiveness 3.74, parking and security 3.80, store cleanliness 3.86, and price affordability and clarity 3.88 (Table 4). Within promotion, information through social media or personal contacts had a mean of 3.96 and discounts 3.92, whereas advertising attractiveness was the weakest item. The finding indicates that the promotion gap concerned message quality and visual appeal more than the mere availability of communication channels.

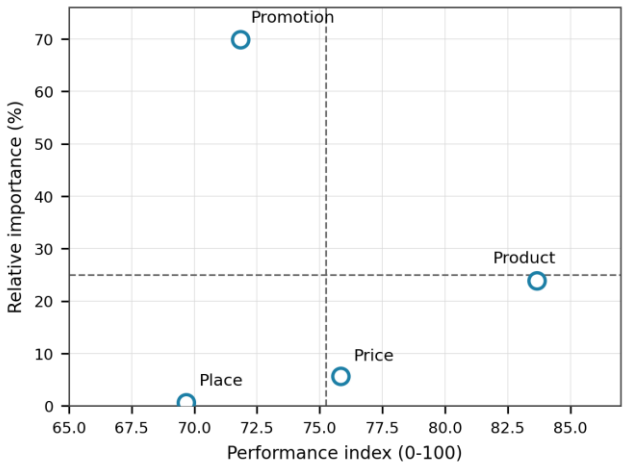
**Table 4. Indicators with the lowest performance**

| Indicator | Code | Mean | Performance index |
|---|---|---|---|
| **Store access** | PL1 | 3.70 | 67.50 |
| **Advertising attractiveness** | PR1 | 3.74 | 68.50 |
| **Parking and security** | PL2 | 3.80 | 70.00 |
| **Store cleanliness** | PL3 | 3.86 | 71.50 |
| **Price affordability and clarity** | PC1 | 3.88 | 72.00 |

*Source: Primary data processed, 2026.*

Figure 1 places promotion in the high-importance, below-average-performance quadrant. Product had high performance and relative importance close to the 25% reference line. Price and place were below the relative-importance threshold, although access, parking, security, and price transparency remained necessary conditions for completing a purchase.

**Figure 1. Importance-performance map of the marketing mix**




# DISCUSSION

The central finding is that promotion was both the only statistically stable partial predictor and the largest contributor to explained variance. Its effect remained positive under OLS, HC3, and paired bootstrap inference, while dominance analysis attributed more than two-thirds of the model's explanatory power to promotion. This convergence gives stronger managerial evidence than a single p-

value. It suggests that, in this retail setting, purchase decisions were particularly responsive to the retailer's ability to make the benefits and availability of hydroponic lettuce visible and understandable.

The result is consistent with evidence that social-media exposure can shape agribusiness shopping behavior [13] and that the effects of marketing-mix elements differ across fresh products and retail formats [23-25]. It also supports the use of the marketing mix as an integrated framework rather than a list of independent tactics [26]. Studies of hydroponic vegetables and Tarakan horticultural markets have not produced a uniform ranking of product, price, place, and promotion [10-16]. The present findings therefore should not be interpreted as a universal claim that promotion always dominates. Instead, they show that the leading marketing lever depends on the product's differentiation, the selling environment, and the information already available to consumers.

Product quality remained strategically important even though its partial coefficient was nonsignificant. Dominance analysis assigned product almost one-quarter of the explained variance, and its performance index was the highest among the four constructs. Freshness, protective packaging, and consistent quality may therefore operate as baseline expectations with relatively little variation among respondents. Once those expectations are met, additional variation in purchase decisions may arise more strongly from communication. This explains why statistical nonsignificance should not be equated with permission to reduce quality: product performance supports the promise that promotion communicates.

The indicator results clarify where promotion should improve. Advertising attractiveness was weaker than discounts and information conveyed through social media or personal contacts. The problem was therefore not simply an absence of channels. It was the capacity of the message and visual execution to explain why hydroponic lettuce is relevant, how fresh it is, when it is available, and how it can be used. Digital information can influence online and everyday purchase intentions [27,28], but communication should remain specific and verifiable. Claims should be anchored in observable attributes rather than exaggerated health promises.

The first managerial priority is to improve advertising appeal through a consistent content system across WhatsApp, Instagram, Facebook, and in-store materials. Useful messages include current freshness, stock or harvest schedules, storage instructions, serving ideas, package size, and transparent prices. A simple visual identity and repeated message structure would make the offer easier to recognize. Promotions should also be linked to supply continuity. Stock-availability messages can reduce consumer search costs, while measured discounts can support trials or bundles without becoming the sole reason for purchase.

The second priority is to protect the operational prerequisites that make promotional promises credible. Freshness and packaging should be monitored continuously; prices should be visible on shelves and digital channels; and selective improvements should address parking, surveillance visibility, store cleanliness, and access. Price and place contributed relatively little to $R^2$ in this sample, but deterioration in either could still prevent transactions or create dissatisfaction. Their lower dominance weights indicate that improvement beyond an acceptable level may yield smaller gains than better promotion, not that these elements can be ignored.

From a sustainable-development perspective, promotion is relevant here not as an end in itself but as a market-coordination mechanism. Clear information on product attributes, prices, and stock can reduce information frictions between local production and urban demand and may help retailers align ordering with a perishable supply. This interpretation contributes to the economic-market dimension of sustainable urban agrifood development [1]. It should not be extended beyond the data: the study did not measure energy use, emissions, water efficiency, food waste, livelihood distribution, or ecosystem outcomes. Therefore, the results do not establish that hydroponic lettuce is environmentally superior to field-based production, a caution consistent with recent life-cycle evidence on hydroponic lettuce [2].

The model's $R^2$ also sets an important boundary. Most variation in purchase decisions lay outside the four measured marketing constructs. Health awareness, habits, trust, service, stock continuity, and household influence may account for part of the remaining variation, consistent with broader psychological accounts of consumer behavior [29,30]. Dominance analysis partitions association within the specified model; it does not transform cross-sectional survey evidence into causality. The results are consequently most applicable to the studied retailer and should be validated before being generalized to other stores or channels.

The study was limited by accidental sampling, 50 respondents, one retail location, and a cross-sectional design. The performance index captured consumer perceptions rather than an operational audit. Future research should use larger multi-retailer samples, transaction data, and repeated observations, and should test health awareness, perceived value, trust, service, and loyalty alongside the marketing mix. Linking consumer decisions with business efficiency and digital connectivity would also strengthen analysis of local agribusiness strategy [31,32].

## CONCLUSION

Promotion is the primary marketing priority for hydroponic lettuce at Super Sayur Fresh 3 because it was the only statistically stable predictor and accounted for 69.87% of the model's explained variance. Product accounted for 23.88% and achieved the highest performance index, confirming that quality should be maintained as the foundation of the retail offer. The most appropriate strategy is to strengthen advertising appeal, communicate verifiable benefits and stock availability, publish consistent digital content, and use discounts selectively. These actions should be implemented while preserving freshness, protective packaging, transparent pricing, store access, security, parking, and cleanliness. Because the evidence comes from a small, single-site cross-sectional sample, the priorities should guide focused managerial experimentation rather than be treated as universal causal effects. Within a sustainable urban agrifood perspective, these findings identify the retail market as one economic coordination node linking local production with urban demand. They should not be interpreted as a full sustainability assessment or as evidence of environmental superiority of hydroponic production.

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