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Output Supply and Inputs Demand Elasticities of Small-Scale Onion Production in Nigeria's Kano State

Elastyczność podaży i popytu na nakłady produkcyjne w produkcji cebuli na małą skalę w nigeryjskim stanie Kano

Abstract. The presented study analyzed the structure of onion production in Nigeria's Kano State using a pseudo-profit function, a symmetric normalized quadratic profit function (translog), and constant elasticity of substitution. A multi-stage sampling technique was used to select a representative sample size of 132 respondents, and a well-structured questionnaire, complemented with an interview schedule, was used to elicit cross-sectional data. Both descriptive and inferential statistics were employed to achieve the specified objectives. Empirically, onion is a viable enterprise in the study area, and input substitution at various combination levels has a complementary effect. Furthermore, the change in the quantity supplied of onion is in conformity with the a priori expectation; the change in output supply is also in conformity with a priori expectations with respect to inputs costs – only seeds, NPK fertilizer, and petrol-engine oil exerted a significant influence. Nevertheless, profit

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in onion production was influenced by output price, wage rate, NPK fertilizer, and petrol-engine oil. However, ten challenges hovered around onion production, *viz.* poor market information, climate change issues, inadequate public-private investment, and problems related to the land tenure system, among others. Therefore, to enhance output supply, the onus lies on policymakers to devise a realistic approach that will address the poor pricing efficiency of input prices in the study area.

Key words: structure, supply, demand, smallholder, onion, nigeria

Synopsis. Przedstawione badanie analizowało strukturę produkcji cebuli w stanie Kano w Nigerii, wykorzystując funkcję pseudozysku, symetryczną znormalizowaną kwadratową funkcję zysku (translog) oraz funkcję o stałej elastyczności substytucji. Zastosowano wieloetapową metodę doboru próby, w ramach której wybrano reprezentatywną grupę 132 respondentów. Dane przekrojowe pozyskano za pomocą starannie opracowanego kwestionariusza, uzupełnionego o wywiady. Do realizacji przyjętych celów badawczych wykorzystano zarówno statystyki opisowe, jak i wnioskowanie statystyczne. Z badań wynika, że uprawa cebuli stanowi opłacalną działalność w analizowanym regionie, a substytucja nakładów na różnych poziomach kombinacji ma efekt komplementarny. Ponadto zmiany w ilości podaży cebuli pozostają zgodne z wcześniejszymi założeniami teoretycznymi; podobnie zmiany w podaży produkcji pozostają zgodne z przewidywaniami względem kosztów nakładów — istotny wpływ wykazały jedynie: nasiona, nawóz NPK oraz olej do silników benzynowych. Zysk z produkcji cebuli był natomiast determinowany przez cenę produktu, stawkę wynagrodzeń, cenę nawozu NPK oraz cenę oleju silnikowego. W badaniu zidentyfikowano także dziesięć głównych barier rozwoju produkcji cebuli, w tym: niewystarczającą dostępność informacji rynkowej, problemy związane ze zmianami klimatycznymi, niewielkie zaangażowanie inwestycyjne sektora publicznego i prywatnego oraz trudności wynikające z systemu własności ziemi. W związku z tym, aby zwiększyć podaż produkcji, decydenci powinni opracować realistyczne strategie, które rozwiążą problem niewystarczającej efektywności cenowej nakładów w badanym regionie.

Słowa kluczowe: struktura, podaż, popyt, drobny rolnik, cebula, Nigeria

Kody JEL: Q12, D24

Introduction

Onions (*Allium cepa*) are a vital component of Nigeria's agricultural landscape – particularly in Kano State, where small-scale production plays a crucial role in both local consumption and regional economic activity. The production of onions in Kano State significantly contributes to the livelihoods of many rural households, providing both income generation and food security. However, the small-scale onion production sector in Kano State faces numerous challenges that impact its productivity and profitability. Among these challenges are the dynamics of output supply and input demand elasticities, which determine how responsive production levels are to changes in input prices and how input demands fluctuate with changes in output prices [Beckman et al. 2022, Vink et al. 2022].

Understanding the elasticities of output supply and input demand is essential for designing effective agricultural policies [Camara and Savard 2023], improving resource allocation [Sadiq et al. 2024a], and enhancing overall productivity in the onion farming sector. These elasticities provide insights into the efficiency of resource use, the sensitivity of production decisions to market conditions, and the potential impacts of policy interventions [Nainggolan et al. 2022, Wijetunga 2016]. While studies on agricultural production elasticities abound globally, there is a notable gap in empirical research specific to small-scale onion production in Kano State, Nigeria. Existing literature often overlooks the unique socio-economic and environmental factors that characterize onion farming in this region, making it imperative to conduct localized research that addresses these specifics.

This study aims to address this gap by empirically investigating the output supply elasticity and input demand elasticity of small-scale onion production in Kano State. Utilizing rigorous econometric methods and primary data collected through surveys, the research seeks to quantify the responsiveness of onion output to variations in production inputs such as labor, land, seeds, and fertilizer. Additionally, it will analyze how input demands respond to changes in input prices and other economic factors within the local context. The findings are expected to provide valuable insights for policymakers, agricultural extension services, and stakeholders involved in the onion production value chain in Kano State. By shedding light on the elasticities governing small-scale onion production, this research aims to inform evidence-based strategies that can promote sustainable agricultural development, enhance farmer livelihoods, and contribute to food security in the region. In summary, this study addresses a critical knowledge gap and aims to offer practical implications for enhancing the efficiency and resilience of small-scale onion production in Nigeria's Kano State. Succinctly, the broad objective was to analyze output supply and input demand elasticities of small-scale onion production in Nigeria's Kano State. The specific objectives were to: estimate the costs and returns to small-scale onion production; determine the input substitution in small-scale onion production; determine the output supply and input demand elasticities of small-scale onion production; and identify the challenges affecting small-scale onion production in the study area.

Literature review

Empirical Review

Empirical evidence highlights the responsiveness of small-scale farmers to changes in input prices and market dynamics, offering insights into productivity and resource allocation. For example, Hayati et al. [2024] explored input production elasticity among smallholder maize farmers in East Java, demonstrating that farmers adjust input use to optimize output and efficiency. This study underscores the broader relevance of elasticity analysis in agricultural contexts, including onion farming in Nigeria's Kano State, to enhance policy and economic interventions. Deribe et al. [2022] evaluated technical efficiency in irrigated onion production in Ethiopia's Central Rift Valley. Input elasticities were found to be inelastic, highlighting the need for better technological interventions.

Mgale [2020] explored price elasticity in Tanzanian onion markets, emphasizing the relationship between producer and market price transmission. Findings suggested significant inefficiencies in value chain integration. Omotesho et al. [2020] studied economic viability in onion production in Benin, reporting that farm size had the highest output elasticity, underlining its importance in achieving economies of scale. Alemu et al. [2018] examined technical efficiency in smallholder onion farming under Ethiopia's Koga Dam. Results indicated constant returns to scale and strong potential for resource reallocation. Bapari et al. [2016] analyzed the economic efficiency of onion production in Bangladesh, finding that seeds and fertilizers significantly impacted production output elasticity. This study underscores the role of input cost management in maximizing returns.

Shettima et al. [2016] assessed economic efficiency in Nigeria's vegetable production, identifying significant room for improving irrigation techniques and input allocations. Nigussie et al. [2015] focused on onion production under small-scale irrigation systems in Ethiopia. Results showed that educational attainment among farmers improved resource utilization and overall productivity. Haile [2015] investigated input elasticities in onion farming in Ethiopia's Kobo District. Findings revealed positive elasticity for inputs like urea and labor, indicating the potential for improving efficiency through resource optimization.

Theoretical Framework

The theoretical framework for analyzing the output supply and input demand elasticities in small-scale onion production is grounded in microeconomic principles of production and consumer behavior. The **production theory** postulates that farmers, as rational economic agents, aim to maximize output or profit given constraints such as input costs, technology, and resource availability. The elasticity of supply reflects the responsiveness of farmers to price changes, emphasizing how economic incentives influence production decisions.

The **demand theory for inputs** complements this by analyzing how input prices and availability affect the quantity of inputs utilized, such as seeds, fertilizers, and labor. This relationship is further framed within the **Cobb-Douglas production function**, which illustrates the marginal productivity of each input and the interplay of inputs in achieving optimal output.

Additionally, the **theory of duality in economics** enables the derivation of input demand functions based on the profit-maximization behavior of producers. This approach incorporates market dynamics, price mechanisms, and resource constraints, offering a comprehensive basis for examining elasticities. By situating the study within these theoretical constructs, the framework effectively captures the complexities of small-scale onion farming and its responsiveness to economic variables in Kano State.

Conceptual Framework

The conceptual framework for analyzing the output supply and input demand elasticities in small-scale onion production in Kano State is structured around the interaction of key variables: economic, agronomic, and institutional factors. It emphasizes the dynamic relationship between onion farmers' decisions, market conditions, and external influences.

1. **Input Factors** – inputs such as seeds, fertilizers, labor, water, and pesticides are central to production. Their availability and price influence input demand elasticity and affect output levels.
2. **Output Supply** – the quantity of onions produced depends on market price, production costs, and farmer responsiveness, captured through supply elasticity.
3. **Market Variables** – market price fluctuations, demand conditions, and value chain dynamics impact both input demand and output supply decisions.
4. **External Influences** – institutional support (e.g., subsidies, training, and market access), climatic conditions, and technology adoption act as moderating variables that shape production efficiency and elasticity responsiveness.
5. **Outcome Variables**: – key outcomes include changes in output levels, input utilization patterns, and overall profitability of onion farming.

This framework integrates economic theory with real-world considerations, guiding the study to evaluate how farmers' resource allocation decisions respond to external stimuli, thereby shaping the sustainability and growth of small-scale onion production in Kano State.

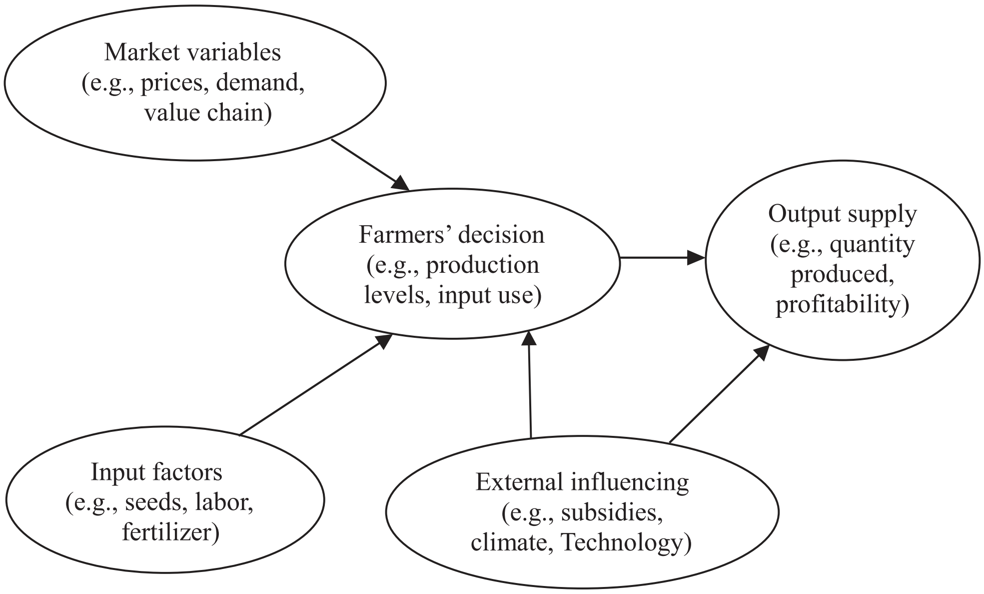

Figure 1. Conceptual framework for onion production analysis
Rysunek 1. Ramy koncepcyjne analizy produkcji cebuli

Source: own elaboration.
Źródło: opracowanie własne.

Research methodology

Kano State, located in northern Nigeria, is one of the country's most populous and economically significant states. It is known for its rich cultural heritage, historical significance, and vibrant agricultural sector. The state is bordered by Katsina State to the northwest, Jigawa State to the northeast, and Kaduna State to the southwest.

Its geographic coordinates range from approximately 11.5°N to 13.5°N latitude and 7.5°E to 9.5°E longitude (Fig. 2). Furthermore, the state exhibits diverse agro-ecological zones, including the Sudan savanna, Sahel savanna, and Guinea savanna. These zones are characterized by varying levels of rainfall, soil types, and vegetation cover, which influence agricultural production systems and cropping patterns within the state. Agriculture is the backbone of the economy in Kano State, employing a significant portion of the population and contributing substantially to the state's Gross Domestic Product (GDP). The state is known for its diverse agricultural activities, including crop cultivation, livestock rearing, and agro-processing industries. Onion production is a prominent agricultural activity in Kano State, with the state being one of the leading onion-producing regions in Nigeria. In other words, the state is renowned for its substantial onion production, with the cultivation of onions being a major economic activity for smallholder farmers in the region. The state's favorable agro-climatic conditions, including sandy soils, warm temperatures, and adequate rainfall during the rainy season, provide conducive environments for onion cultivation. Smallholder farmers play a significant role in onion production, employing traditional farming practices alongside modern techniques.

The state is characterized by a diverse mix of ethnic groups, including the Hausa, Fulani, Kanuri, and others, each with its unique cultural heritage and farming traditions. Traditional institutions, social networks, and community-based organizations play crucial roles in shaping agricultural practices, resource management, and collective decision-

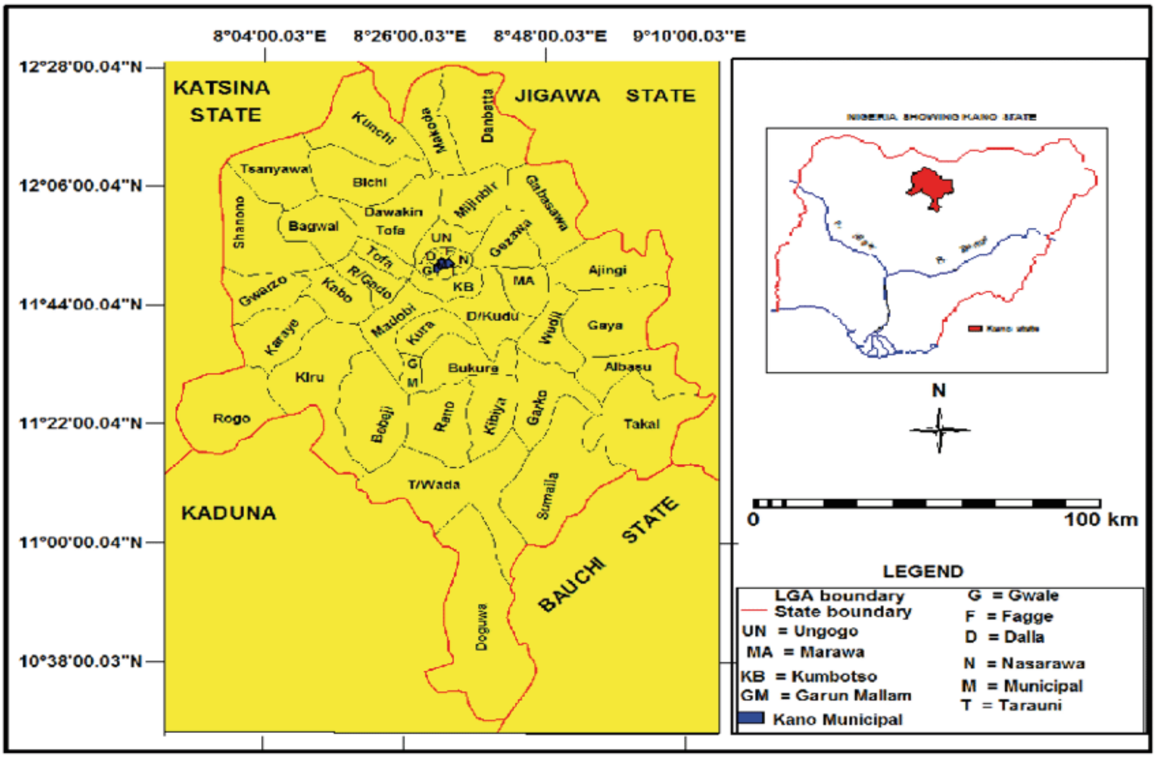

Figure 2. Map of Kano State

Rysunek 2. Mapa Kano State

Source: [Nwagbara 2015].

Źródło: [Nwagbara 2015]

Table 1. Sampling procedure and sample size
Tabela 1. Procedura pobierania próbek i wielkość próby

Zones	LGAs	Villages	Sample size
	Bebeji	Kiriya	4
		Babuda	4
		Dirbawa	4
		Dorawar Sallau	4
Zone I	Garun Malam	Kadawa	4
		Garin Babba	4
		Karfi	4
	Kura	Imawa	4
		Kura	4
		Jan Garu	4
	Rano	Rurum	4
		Sabuwar Kaura	4
		Diggol	4
	Dambatta	Gwanda	4
		Zakirai	4
		Kasuwar Kuka	4
Zone II	Kunchi	Zanchi	4
		Sabon Ruwa	4
		Dan Marke	4
	Makoda	Dunawa	4
		Koguna	4
		Baita	4
	Minjibir	Dan Madanho	4
		Wasai	4
		Gidan Gayawa	4
	Dawakin Kudu	Sarai	4
		Yan Baran	4
		Garin Dau	4
Zone III	Warawa	Katarkawa	4
		Dan Hawa Giwa	4
		Tsibiri	4
	Wudil	Lajawa	4
		Wudil	4
3	11	33	132

Source: KNADP and Reconnaissance survey, 2023
Źródło: KNADP i badanie rozpoznawcze, 2023

making processes within rural communities. Despite its agricultural potential, Kano State faces various challenges, including land degradation, water scarcity, pest and disease outbreaks, limited access to inputs and credit facilities, and inadequate infrastructure. However, the state also presents opportunities for innovation, investment, and sustainable development initiatives aimed at enhancing agricultural productivity, resilience, and environmental sustainability.

Using a multi-stage sampling technique, a total of 132 onion farmers constituted the sample size. Firstly, given the prevalence of onion cultivation in the state, all the stratified ADP (Agricultural Development Project) zones, namely Zones I (Rano), II (Dambatta), and III (Gaya), were adopted. Secondly, a proportionate sampling technique that adopted a scale of 30% was used to select the representative Local Government Areas (LGAs). Notably, given the high density of onion production in Zones I and II, all the LGAs totaling 27 constituted the sampling frame. In contrast, in Zone III, only 11 out of the 17 LGAs comprised the sampling frame, as the remaining six LGAs are metropolitan areas with little or no onion farming activities. Succinctly, from Zones I and II, and Zone III, four and three LGAs each were randomly selected, thus giving a total selection of 11 LGAs. Fourthly, from each of the selected LGAs, three villages were randomly selected. Lastly, due to the absence of a finite sampling frame of onion farmers, using a freelance survey, four farmers were randomly selected from each of the chosen villages, thus giving a total sample size of 132 farmers. Further, using an easy-cost route approach, a well-structured questionnaire coupled with an interview schedule was used to elicit cross-sectional data on onion production during the 2023 cropping (rainy) season. Objectives I, II, III, and IV were achieved using pseudo-profit function, constant elasticity of substitution (CES), symmetric normalized quadratic profit function (trans-log), and exploratory factor analysis complemented with Kendall's coefficient of concordance and *k*-means cluster model.

Empirical Model

Farm budgeting technique. The farm budgeting technique gives a blurb of enterprise's profitability. Following Sadiq et al. [2024a, b] the model is given below:

$NFI = TR - TC$

$GM = TR - TVC$

$ROI = GM/TVC$

$ROCI = NI/TC$

where:
TR – total revenue,
TC – total cost ($TVC + TFC$),
TVC – total variable cost;
TFC – total fixed cost,
ROI – return on Naira invested,
*ROC*I – return on capital invested.

Constant Elasticity of Substitution (***CES***). Following Hanningsen and Hanningsen [2011], CES production with two inputs in its formal specification is as follows:

$$Y_i = \gamma\left[\delta X_1^{-\rho} + (1-\delta)X_2^{-\rho}\right]^{\frac{-v}{\rho}}$$

where:
Y_i – output quantity;
X_{1-2}– input quantities;
$\gamma \in [0, \infty]$ – determines the productivity;
$\delta \in [0, 1]$– determines the optimal distribution of the inputs (optimal distribution parameter) $(0 < \delta < 1)$;
$\rho \in (-1,0) \cup (0,\infty)$ determines the (constant) elasticity of substitution (substitution parameter), which is $\sigma = \frac{1}{1} + \rho(\rho \geq -1)$
$v \in [0, \infty]$ – is equal to the elasticity of scale (return to scale parameter).

For elasticity of substitution (σ), the following relationships between (σ) and (ρ) hold: $\sigma = \infty$, then ($\rho = -1$): CES takes a linear form and the inputs are perfect substitute so that the farmers have no special preference for any of the inputs.

$\sigma = 1$, then ($\rho = 0$): CES becomes a Cobb-Douglas function and expressed a perfect balance between substitution and complementary effects. It implies unity elasticity of substitution between the two inputs.

$\sigma = 1$, then ($\rho > 0$): CES becomes a production function with significant complementarity's effect between inputs.

$\sigma > 1$, then ($\rho < 0$): CES function shows inputs that are partial substitutes.

$\sigma = 0$, then ($\rho < \infty$): CES takes the form of a Leontief production function. This means that the optimal input combination or substitution in the production process does not depend on input prices but is fully determined by the parameters defining the production process.

The formal specification of CES for three inputs is as follows:

$$Y = \gamma\left(\sum_{i=1}^{n} \delta_i x_i^{-\rho}\right)^{\frac{-v}{\rho}}$$

with $= \sum_{i=1}^{n} \delta_i = 1$

where:
n – the number of inputs,
X_{1-n} – the quantities of n inputs.

$$Y = \gamma\left[\delta(\delta_1 x_1^{-\rho} + (1-\delta_1)x_2^{-\rho})^{\rho/\rho} + (1-\delta)x_3^{-\rho}\right]^{\frac{-v}{\rho}}$$

The formal specification for CES production for four inputs is as follows:

$$Y = \gamma\left[\delta(\delta_1 x_1^{-\rho 1} + (1-\delta_1)x_2^{-\rho 1})^{\rho/\rho 1} + (1-\delta)(\delta_2 x_3^{-\rho 2} + (1-\delta_2)x_4^{-\rho 2})^{\rho/\rho 2}\right]^{\frac{-v}{\rho}}$$

Symmetric normalized quadratic profit function (trans-log)

$$\pi(p,z) = \sum_{i=1}^{n}\alpha_i p_i + \frac{1}{2}w^{-1}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}p_i p_j + \sum_{i=1}^{n}\sum_{j=1}^{m}\delta_{ij}p_i z_j + \frac{1}{2}w\sum_{i=1}^{m}\sum_{j=1}^{m}\gamma_{ij}z_i z_j$$

with π = profit, p_i = netput prices, z_i = quantities of fixed inputs, $w = \sum_{i=1}^{n}\theta_i p_i$ = price for normalization, θ_i = weights of prices for normalization, and α_i, β_{ij}, δ_{ij} and γ_{ij} = coefficients to estimated.

The netput equations (output supply in input demand) can be obtained by Hotelling's Lemma $\left(q_i = \frac{\partial\pi}{\partial pi}\right)$:

$$x_i = \alpha_i + w^{-1}\sum_{j=1}^{n}\beta_{ij}p_j + \frac{1}{2}\theta_i w^{-2}\sum_{j=1}^{n}\sum_{k=1}^{n}\beta_{jk}p_j p_k + \sum_{i=1}^{m}\delta_{ij}z_j + \frac{1}{2}\theta_i\sum_{j=1}^{m}\sum_{k=1}^{m}\gamma_{jk}z_j z_k$$

Noteworthy, Output (kg); inputs: labor (Manday), Seed (kg), NPK fertilizer (kg), pesticides (liter), Herbicides (liter), Petrol (liter), Engine oil (liter), Depreciation on capital item (NGN), and farm size (hectare).

Results and discussion

Costs and Return(s) to Onion Production

The breakdown of the costs and return structures of onion production in Table 2 showed the cost of cultivation cum total variable cost and fixed cost to be NGN 456,567.60k, NGN 417,873.60k, and NGN 38,694.05k, respectively. Of the cost of cultivation, the proportions of the total variable cost and fixed cost were 91.53% and 8.47%, respectively. Additionally, the costs incurred on labor, followed by NPK fertilizer, were the highest, while the incurred cost on engine oil was the lowest. Consequently, the high cost proportion of labor might be attributed to the intensive agronomic practices involved in onion production from the pre-planting to the harvesting stage. Likewise, the inability of the farmers to substitute labor for herbicides due to resource scarcity is a contributory factor. Noteworthy, the cost of production (i.e., cost incurred per 1 kg of onion was NGN 6215.22k).

Furthermore, the observed short- and long-run profit margins per hectare were NGN 952,300.60k and NGN 913,606.50k. Besides, nuancing the benefits that accrued to the enterprise, respectively, the benefit-cost ratio indexes in the short- and long-run were 2.28 (*ROI*) and 2.00 (*ROCI*). Thus, for the former and latter, for every Naira invested, the cost – i.e., NGN 1– is returned and profits of NGN 1.28k and NGN 1.00 were gained. However, using the ROCI to assess credit solvency, i.e., the ability of the farmers to repay borrowed capital without default or delinquency, at the prevailing cost of credit (interest rate) of 14%, the farmers will be able to retire the principal plus the interest and still gain 86 kobo (cent). Succinctly, it can be concluded that onion production in the study area is not only profitable, but also a viable venture.

Table 2. Costs and return structure of onion production
Tabela 2. Koszty i struktura zwrotu z produkcji cebuli

Items	Unit	Qty	Unit price	Total value	%
Labor	manday	93.21	1665.50	155236.30	34
Seed	kg	2.70	26670.45	72045.44	15.78
NPK fertilizer	bag (50 kg)	4.64	23496.21	109106.20	23.9
Pesticides	liter	2.38	3529.17	8389.05	1.84
Herbicides	liter	2.45	3196.97	7836.80	1.72
Petrol	liter	159.35	185	29479.41	6.46
Engine oil	liter	1.47	2400	3526.73	0.77
i	14% of TVC	32253.70		32253.70	7.06
DCI	NGN	7655.69		7655.69	1.68
Rent	hectare		8000	8000	1.75
Managerial Cost	10% of TVC		23038.36	23038.36	5.05
TVC				417873.60	91.52
TFC				38694.05	8.47
TC				456567.60	
Output	bag (80kg)	73.46	18543.18	1362174	
Lease-out	hectare	1	8000	8000	
TR				1370174	
Gross Margin				952300.60	
Net Farm Income				913606.50	
ROI				2.28	
ROCI				2.00	
CP				6215.22	

IWC = Interest on working capital; DCI = Depreciation on capital items; CP = Cost of production (i.e., cost per unit of output); NGN= Naira; k = Kobo

Source: Field survey, 2023.
Źródło: Badanie terenowe, 2023.

Inputs Substitution

Keeping land constant (Table 3), the CES production function for two inputs, *viz.* lumped working capital and labor, showed all the parameter estimates in the model to be within the plausible margin of a 10% probability level, thus confirming the fit of the model for the specified crop using lumped capital and labor production inputs. Empirically, it was observed that these two inputs accounted for 74.10% of the variation in the output of onion, as evidenced by the coefficient of multiple determination (R^2) value of 0.7410. Furthermore, the managerial efficiency parameter (gamma) coefficient of 1.107 implied that managerial efficiency accounted for 1.107% of the productivity of onion production in the study area. However, the low value of managerial efficiency clearly points to a poor decision-making process by most of the farmers regarding the business viability of onion production, and the possible reason might be due to a low educational level, which affected technological contributions to onion output. Besides, it showed that the use of primitive implements dominates the production of onion; i.e., while raising the elasticity of substitution, the yield of onion can be increased, but its effect may not be potentially large due to the use of conventional farm tools and crude implements. Based on a general normalized CES function, as reported by Idisi et al. [2020], Klump and de La Grandville (2000) presented a formal proof of the foregoing conjecture. Furthermore, the return to scale parameter (nu) coefficient of 1.06733, in this case variable proportion to scale, given that land is held constant, showed that the farmers were experiencing an increasing return to scale in the yield of onion. This stage of production is irrational (stage I) as MPP >APP; consequently, the farmers can increase their yield level as there is still room for input mix expansion, keeping in view the input prices or costs in order to attain the economic optimum level of production in stage II, i.e., the rational production level. Moreover, to obtain an optimal distribution of lumped capital and labor for efficient onion production in the study area, the input substitution between lumped capital and labor should be in the ratio of 0.64187 to 0.35813, respectively, as evidenced by the distribution parameter (Delta) coefficient of 0.64187. Further, the constant elasticity of substitution coefficient being less than 1, i.e., 0.5477, implies that the combination of lumped capital and labor in the production of onions has a significant complementary effect. Besides, it indicates that in the study area, farmers used lumped capital to complement labor in enhancing the productivity of onions. Succinctly, these farmers used more labor than lumped capital in the production of onions in the study area. In spite of the cultivation of onions on a small scale, the complementarity effect of lumped capital over labor was marginal, thus indicating a moderate financial investment in the enterprise. The possible reason could be the cost implications of the agronomic practices involved in onion production in the study area.

On the other hand, holding land constant, for the three inputs *viz*. labor, partial lumped working capital and energy/fossil fuel (Table 3), except for substitution parameter 1 (rho 1), all the parameter estimates of the CES production function were within the acceptable margin of 10% degrees of freedom, thus implying the fitness of the model for the crop using labor, partial lumped working capital, and energy/fossil fuels as the production inputs. The coefficient of multiple determination (R^2) being 0.8219 means that these three inputs accounted for 82.19% of the variation in the yield of onion. The efficiency parameter (gamma) coefficient being 1.269 implied that managerial efficiency, attributed to decision-making, contributed 1.269% to the yield of onion. Besides, this low contribution of management could be attributed to the low educational level of most of the farmers, which has affected the efficiency of the farmers in exploring technological potentials in the production of onion. In addition, the potential effect of management in raising the productivity of onion is minimal, and this may not be unconnected with the use of rudimentary farm implements in the cultivation of onion in the study area. Further, to achieve efficient production of onions in the study area, optimal substitutions of labor for partial lumped working capital and energy/fossil fuels should be in the ratios of 0.72947 to 0.27053 and 0.63887 to 0.36113, respectively, as evidenced by their respective distribution parameters (Delta and Delta 1). Moreover, the empirical evidence revealed that the farmers were operating at constant returns to scale, as indicated by the return to scale parameter (nu) coefficient of 1.00. Thus, the study advises the farmers to be cautious at this rational stage of production and to work meticulously on attaining the economic optimum point, given that any input mix expansion will exert the same marginal effect on the yield level of onions. Furthermore, it was observed that in the production of onions, the constant elasticities of substitution of labor for lumped partial working capital (0.85418), as well as the nested labor and lumped partial working capital for energy/fossil fuels (0.46342), were less than unity, as evidenced by Hicks-McFadden (direct) and Allen-Uzawa/Morishima (partial) elasticities of substitution parameters, respectively. This implies that labor and partial lumped working capital, as well as labor and lumped partial working capital combined versus energy/fossil fuels inputs in the production of onions, have significant complementarity effects. Therefore, for the direct elasticity, the farmers used labor to complement lumped partial working capital for onion yield enhancement; whereas for the partial elasticity, the farmers combined labor-lumped partial working capital to complement energy/fossil fuel in enhancing the onion's productivity in the study area. Consequently, for the former, farmers used more lumped partial working capital than labor, while for the latter, the farmers used more energy/fossil fuels than nested labor-lumped partial working capital. However, the results showed the indispensability of the three inputs used in the production of onion in the study area. Nevertheless, for the direct elasticity, it can be inferred that the resource-poor status of the farmers could be the possible reason for the high deployment of human labor in the production of onion; while for the partial elasticity, the challenge of climate change – dry spell – could be the possible reason that forced the farmers to use an appreciable quantity of fossil fuels/energy for irrigation purposes in order to achieve high productivity of onion in the study area.

For the four input combination (labor, seed, biocides, and energy/fossil fuels); (Table 3), *ceteris paribus*, the CES function was found to fit the specified equation, as evidenced by most of its estimated parameters being different from zero at a 10% level of significance. Notably, 79.46% of the variation in the output of onion is explained by the joint influence of all the inputs included in the model, as indicated by the R^2 value of 0.7946. The significance of the efficiency parameter indicates that there was significant technological progress in the production of onion; however, due to the use of rudimentary implements for cultivation, coupled with a low education level that masked the management of the firm, the potential effect of the technical progress was small, i.e., 1.088%, as evidenced by the efficiency parameter coefficient value of 1.088. Furthermore, both optimal distribution parameter estimates were significant, indicating the presence of proportional substitution between these inputs. For the distribution parameter (Delta), the coefficient value of 0.67332 implies that to achieve efficient onion production in the study, an optimum distribution of labor for seed should be in the proportion of 0.67332 and 0.32668, respectively. Besides, for the distribution parameter (Delta 1), the coefficient value of 0.63904 means that an optimum substitution of labor for biocides in the ratio of 0.63904:0.36096 is needed for the farmers to achieve efficient onion production. Nevertheless, for labor and energy/fossil fuels, the ratio of 0.48577 to 0.51423, respectively, is the optimum substitution required by the farmers to have efficient onion production. Moreover, the result showed that the farmers were operating at an increasing proportion to scale, as indicated by the coefficient value of the return to scale parameter (1.07149). Therefore, given that the operational scale level of production is irrational, keeping in view the input and output prices, farmers are advised to increase their output level by adopting an appropriate input mix to achieve economic efficiency in onion production. Furthermore, as evidenced by the significance of CES coefficients that are within the acceptable margin of a 10% error gap, the constant elasticity of substitution for onion production at various input combinations was less than unity, thus implying a significant complementarity effect between inputs at various levels of combination in the production of onions in the study area. The complementarity effects of input combinations *viz.* labor and seed; and biocides and energy/fossil fuels – as evidenced by their respective Hicks-McFadden (direct) elasticity of substitution mean that more seed than labor is used in the cultivation of onions for the former, while for the latter, the farmers used more energy/fossil fuels than biocides in the cultivation of onions. Nuancing empirically, it can be inferred that the farmers used improved seed varieties and fossil fuels for the purpose of irrigation to improve the yield of onions. Nevertheless, the complementarity effect between combined labor-seed and combined biocides-energy/fossil fuels, as indicated by the Allen-Uzawa (partial) elasticity of substitution, means that more combined biocides and energy/fossil fuels than combined labor and seed are used by the farmers to cultivate onion production in the study area. Succinctly, the effect of climate change, attributable to erratic rainfall, which in turn makes the crop highly susceptible to pests and diseases, along with a favorable market for the crop, compels the farmers to invest more in the purchase of biocides and energy/fossil fuels for higher output in the study area.

Table 3. Inputs substitution at various levels
Tabela 3. Substytucja nakładów na różnych poziomach

Variables	Two-inputs	Three-inputs	Four-inputs
γ	1.1072 (6.677)***	1.2690(8.329)***	1.0881(7.553)***
δ	0.6418 (17.19)***	0.7294(22.03)***	0.6733(16.717)***
δ_1	–	0.6388(25.99)***	0.6390(17.03)***
δ_2	–	–	0.4857(17.42)***
ρ	0.8258(1.937)*	0.1707(0.439)^{NS}	0.2502(0.615)^{NS}
ρ_1		1.1578(3.746)***	0.6336(1.743)*
ρ_2			0.6705(1.873)*
v	1.0673(17.51)***	1.0052(19.73)***	1.0714(19.23)***
$\delta_{1\text{–}2}$	0.5477(4.282)***	0.8541(3.011)**	0.7998(3.073)**
$\delta_{3\text{–}4}$			0.6121(4.493)***
$\delta_{1,2\text{–}3,4}$		0.4634(6.982)***	0.5986(4.667)***
R^2	0.7410	0.8219	0.7946

Significant at ***1%;**5%;*10%; NS = Non-significant; lumped working capital (seeds; biocides – NPK fertilizer, herbicides and pesticides; and energy/fossil fuel – petrol and engine oil); partial lumped working capital (excluding energy/fossil fuels).

Source: Field survey, 2023.
Źródło: Badanie terenowe, 2023.

Elasticities of Output Supply and Inputs Demand

Presented in Table 4 are the parameter estimates of the symmetric normalized quadratic (translog) profit function for onion production in the study area. Additionally, convexity was achieved in the non-linear least squares estimation. Empirically, of the 74 parameter estimates, 28 estimated coefficients were asymptotically significant at the acceptable margin of the 10% probability level. Notably, the coefficients of factor prices, such as labor, NPK fertilizer, and petrol-engine oil, had a negative significant influence on profit, whereas the coefficient of the output price had a significant positive influence on profit, thus conforming to a priori expectations. However, the values of the estimated coefficients were greater than unity, implying that the output-input prices had an elastic effect on profit. Furthermore, all the aforementioned coefficients were elastic in nature; thus, a slight increase in the prices of the former and latter will lead to a more than proportionate decrease and increase, respectively, in the output of onion. However, the non-significance of the seed coefficient might be attributed to the use of third filial generation improved seed varieties, while the non-significance of pesticides and herbicides might be associated with low usage due to a high substitution effect with labor. Notably, the poor substitution of pesticides and herbicides for labor has been justified in the discussion of costs and returns. Furthermore, in descending order, the coefficient values of labor, petrol-engine oil, and NPK fertilizer prices being the highest imply a high dependency of profit on these prices.

Shown in Table 5 are the elasticities of the output supply and inputs demand. The own-price elasticity of all the inputs demand was negative (ranging from –0.139 to –4.869), thus implying that all the estimated inputs' demand slopes downward as required for the convexity of the profit function. Except for the prices of labor and herbicides, which were inelastic, all the input prices were elastic, meaning that an increase in the input prices of the former will lead to a less than proportionate decrease in their demand, while in the case of the latter, the resultant effect will be more than a proportionate increase in their demand. Succinctly, the input demand elasticity of the former implied they are necessary goods, while that of the latter implied they are luxury goods. Notably, only the own-price elasticities of seeds, NPK fertilizer, and petrol-engine oil were found to be significant. Therefore, for a unit increase in the prices of seeds, NPK fertilizer, and petrol-engine oil, respectively, by 1% – their respective demand will plummet by 3.061, 3.467, and 4.869%.

Furthermore, the output price of onion (a change in quantity supplied) had a significant and positive effect on supply, thus indicating the upward slope of the onion output supply curve. This conforms to the a priori expectation as postulated by the theory of supply. Thus, for a percent increase in the output price (0.0066), the output supply will increase by 0.0066%. Nevertheless, all the variable factor prices had a negative effect on output supply (change in supply); however, only seeds, NPK fertilizer, and petrol-engine oil prices were significant. Likewise, fixed inputs *viz.* land and depreciation on capital items, were inversely related to the output supply. The negative elasticities with respect to the variable inputs implied that there would be a decline in input use in the eventuality of a price hike, thus plummeting the supply of onion output. Given the price coefficients of seeds, NPK fertilizer, and petrol-engine oil being 0.0499, 0.041, and 0.0118, respectively, for a unit price increase (1%), the resultant decrease in their demand will lead to a decline in onion output by 0.0499, 0.041, and 0.0118%. Also, the negative elasticity of land with respect to the output means that diseconomies of scale prevailed in the production of onion

Table 4. Estimated symmetric normalized quadratic profit function for onion production
Tabela 4. Oszacowana symetryczna znormalizowana funkcja zysku kwadratowego dla produkcji cebuli

Parameters	Coefficient	Stand error	*t*-statistics	Parameters	Coefficient	Stand error	*t*-statistics
α 1	50.174	14.109	3.556***	β 4 4	–52.411	16.895	3.102***
α 2	–31.897	9.5121	3.353***	β 4 5	–2.8727	11.881	0.241^{NS}
α 3	–5.8041	4.4898	1.292^{NS}	β 4 6	–14.51	15.537	0.933^{NS}
α 4	–14.582	5.8065	2.511**	β 4 7	0.9507	11.149	0.085^{NS}
α 5	–5.8271	4.2479	1.371^{NS}	β 5 1	–0.6244	2.9185	0.213^{NS}
α 6	–7.6296	4.9965	1.526^{NS}	β 5 2	7.0061	9.5844	0.731^{NS}
α 7	–22.423	7.8673	2.85***	β 5 3	–8.126	8.5469	0.951^{NS}
β 1 1	0.3099	1.2017	0.257^{NS}	β 5 4	–2.8727	11.881	0.241^{NS}
β 1 2	1.2519	3.002	0.417^{NS}	β 5 5	–20.965	14.394	1.456^{NS}
β 1 3	–2.4283	2.154	1.127^{NS}	β 5 6	–8.2628	13.384	0.617^{NS}
β 1 4	–2.0114	3.1942	0.629^{NS}	β 5 7	33.845	10.564	3.203***
β 1 5	–0.6244	2.9185	0.213^{NS}	β 6 1	2.8302	3.7601	0.752^{NS}
β 1 6	2.8302	3.7601	0.752^{NS}	β 6 2	–20.237	13.015	1.554^{NS}
β 1 7	0.672	3.1197	0.215^{NS}	β 6 3	–20.689	11.337	1.824*
β 2 1	1.2519	3.0018	0.417^{NS}	β 6 4	–14.51	15.537	0.933^{NS}
β 2 2	–4.5093	16.303	0.276^{NS}	β 6 5	–8.2628	13.384	0.617^{NS}
β 2 3	–16.964	6.3152	2.686***	β 6 6	3.9965	23.435	0.171^{NS}
β 2 4	11.206	10.488	1.068^{NS}	β 6 7	56.873	13.569	4.191***
β 2 5	7.0061	9.5844	0.731^{NS}	β 7 1	0.6721	3.1197	0.215^{NS}
β 2 6	–20.237	13.015	1.554^{NS}	β 7 2	22.246	10.364	2.146**
β 2 7	22.246	10.364	2.146**	β 7 3	13.651	7.3126	1.866*
β 3 1	–2.4283	2.154	1.127^{NS}	β 7 4	0.9507	11.1495	0.085^{NS}
β 3 2	–16.964	6.3152	2.686***	β 7 5	33.845	10.564	3.203***
β 3 3	–25.091	9.8011	2.56***	β 7 6	56.873	13.569	4.191***
β 3 4	59.648	9.4758	6.294***	β 7 7	–128.23	14.621	8.771***
β 3 5	–8.126	8.5469	0.951^{NS}	δ 1 1	5.0831	–2.9573	1.718*
β 3 6	–20.689	11.337	1.824^{NS}	δ 1 2	–0.0619	3.1724	0.019^{NS}
β 3 7	13.651	7.3126	1.866*	δ 2 1	7.4733	–1.9611	3.811***
β 4 1	–2.0114	3.1942	0.629^{NS}	δ 2 2	0.1531	2.0941	0.073^{NS}
β 4 2	11.206	10.488	1.068^{NS}	δ 3 1	10.354	–0.7131	14.519***
β 4 3	59.648	9.4758	6.294***	δ 3 2	0.451	0.6807	0.662^{NS}

Variable	Coefficients	Standard error	*t*-statistics
δ 4 1	7.9791	–1.0508	–7.592
δ 4 2	0.1936	1.0681	0.181
δ 5 1	8.403	–0.6276	–13.38
δ 5 2	0.1353	0.5725	0.236
δ 6 1	8.2907	–0.7209	–11.49
δ 6 2	–0.0264	0.6484	0.04
δ 7 1	3.3524	–1.6095	2.082
δ 7 2	0.4363	1.7094	0.255
Υ 1 1	0.0255	1.1701	0.021
Υ 1 2	0.0865	–0.955	0.091
Υ 2 1	0.0865	–0.955	0.091
Υ 2 1	0.0239	1.0326	0.091
R^2		0.9604	

Source: Field survey, 2023.
Źródło: Badanie terenowe, 2023.

in the study area (Table 6). This is expected as the operational farm holdings of the majority of farmers are marginal. Likewise, the negative elasticity of depreciation on capital items implies that the cost implications of wear and tear decreased the output supply of onions. However, the significance of the fixed costs couldn't be ascertained, as the *R* software estimation guide used had no provision for it. Nevertheless, the price and cross-price elasticities of supply were inelastic, which means that a change in the prices of output-inputs would lead to a less than proportionate change in the supply of onion output. By implication, onion is a necessary commodity in the study area. Generally, it can be inferred that the supply of onions is influenced by its output price and the prices of improved seeds, NPK fertilizer, and petrol-engine oil. Therefore, the study advises policymakers to devise a realistic means of subsidizing these inputs, as hyperinflation occasioned by petrol subsidy removal has permeated the price efficiency of these inputs. Besides, particularly regarding petrol-engine oil, farmers are advised to adopt energy-friendly tools that use alternative green energy sources (e.g., solar-driven water pump machines). Though expensive, access to these machines and others is possible through social capital pooling (cooperative organization) and support from policymakers (private and public).

Table 5. Output supply and variable inputs demand elasticities
Tabela 5. Elastyczność podaży produkcji i popytu na zmienne nakłady

Variable	P_Y	P_L	P_S	P_N	P_P	P_H	P_{PE}
				Elasticity coefficients			
Output (Y)	0.0066	0.0256	–0.0499	–0.041	–0.0121	0.0591	0.0117
Labor (L)	0.0397	–0.1393	–0.5261	0.3472	0.2164	–0.6211	0.6832
Seed (S)	–0.3041	–2.0697	–3.0608	7.276	–0.9858	–2.506	1.6506
NPK fertilizer (N)	–0.1355	0.7401	3.9421	–3.4667	–0.1885	–0.9514	0.0602
Pesticides (P)	–0.1088	1.2516	–1.4492	–0.5116	–3.7196	–1.4622	5.9998
Herbicides (H)	0.5128	0.5128	–3.5672	–2.4997	–1.416	–0.6893	9.7593
Petrol/Engine oil (PE)	0.0225	0.8466	0.5199	0.035	1.2856	2.1595	–4.8693
				***t*–statistics**			
Output (Y)	2.2693	0.4223	–1.1449	–0.6355	0.207	0.7822	0.1877
Labor (L)	0.4223	–0.2763	–2.6901	1.0688	0.733	1.5508	2.1411
Seed (S)	–1.1449	–2.6901	–2.5631	6.3017	0.9508	1.8241	1.8621
NPK fertilizer (N)	–0.6355	1.0688	6.3017	–3.1065	0.2414	0.9325	0.0822
Pesticides (P)	–0.207	0.733	–0.9508	0.2414	1.4556	0.6161	3.2028
Herbicides (H)	0.7822	–1.5508	–1.8241	0.9325	0.6161	0.1714	4.1931
Petrol/Engine oil (PE)	0.1877	2.1411	1.8621	0.0822	3.2028	4.1931	8.7694

P = Price (s)

Source: Field survey, 2023.
Źródło: Badanie terenowe, 2023.

Table 6. Fixed inputs demand elasticities
Tabela 6. Elastyczność popytu na stałe nakłady

Variable	Farm size	DCI
Output (Y)	–0.01803	–0.001003
Labor (L)	–0.03935	0.053711
Seed (S)	–0.21067	0.495163
NPK fertilizer (N)	–0.08851	0.124481
Pesticides (P)	–0.24991	0.224213
Herbicides (H)	–0.23855	–0.02787
Petrol/Engine oil (PE)	–0.02214	0.158356

DCI = depreciation on capital item.

Source: Field survey, 2023.
Źródło: Badanie terenowe, 2023.

Challenges Affecting Onion Production

A perusal of the challenges showed that any challenge with a threshold below 2.0 is a very severe constraint that affects onion production. Few examples include high perishability, post-harvest losses, and inadequate storage facilities (Table 7). Further, the challenges with a threshold value equal to 2.0 and less than 3.0 are perceived as severe constraints (e.g., high cost of transportation, problems with the land tenure system, etc.); challenges with a threshold value of 3.0 are perceived as moderate constraints (e.g., poor access to market information, seed viability constraints, etc.). Generally, the farmers have a negative/unfavorable perception of the challenges affecting onion production, as evidenced by the grand mean index value of 2.61, which is less than the Likert scale mean threshold value of 3.5. Besides, 43.61 percent of the respondents had negative perceptions of the challenges that affected onion production, as shown by the perception index value of 0.4361. Nevertheless, the Kendall's coefficient of concordance showed that the farmers did not unanimously agree with the ranking of these challenges, as indicated by the significant KCC index value of 0.201.

Furthermore, the factor analysis conducted on the barriers affecting small-scale onion farmers, utilizing the Varimax rotation method (Table 7), revealed noteworthy insights. The computed Kaiser-Meyer-Olkin (KMO) index, standing at 0.769, along with a statistically significant Bartlett's sphericity test (BST), signifies the suitability of the dataset for factor analysis. This is corroborated by a review of the KMO value, which surpasses the recommended threshold value of 0.50 set by Kaiser [1974], Sadiq [2023], and Sadiq et al. [2024b]. Such statistical indicators establish a robust foundation for deriving meaningful factors affecting onion production among small-scale farmers. The factor extraction process, guided by item loadings, yielded eight distinct components representing barriers to onion production. These components are elucidated as follows: Market information problem (F1), Climate change problem (F2), Low public-private investment problem (F3), Land tenure problem (F4), Infrastructure problem (F5), Capital problem (F6), Storage facilities problem (F7), Postharvest losses problem (F8), Theft/poaching problem (F9), and Agronomic practices knowledge problem (F10).

The factors affecting onion production and market success are multifaceted, and a comprehensive understanding of these factors is crucial for effective planning and resource allocation. This study explores the explicit barriers associated with various factors, shedding light on critical challenges faced by farmers in optimizing their agricultural practices and navigating market dynamics. In the realm of "market information problem" (factor one), barriers manifest prominently in the form of poor access to market information (.728) and inadequate awareness of postharvest technology usage (.622). Notably, poor access to market information emerges as the most formidable challenge within this factor, underscoring its pivotal role as a major constraint in the context of market information. This revelation emphasizes the urgent need for interventions aimed at enhancing farmers' access to timely and accurate market data. Factor two delves into obstacles related to technical advice on input usage (.882) and climate change constraints (.715). Here, climate change constraints take center stage with the highest loading, signifying their significance as the primary barriers to climate change challenges. Acknowledging and addressing these constraints is vital for building resilience and sustainability in agriculture, particularly in the face of a changing climate.

Factor three encompasses barriers such as low public and private investment (.737) and challenges in leasing or renting farmland (.596). The highest loading within this factor is attributed to low public and private investment, indicating its pivotal role as the most prominent barrier concerning low public-private investment. Effective strategies to attract and mobilize investments are imperative to bolster the agricultural sector and propel economic growth. Factor four sheds light on obstacles like the land tenure system (.552), and disease and insect pests (.431). Additionally, recognizing the significance of land tenure and pest management is crucial for fostering a conducive environment for agricultural development.

Factor five focuses on barriers associated with poor infrastructure (.809) and high perishability (.494). These challenges highlight the critical need for infrastructure development to facilitate efficient agricultural operations and minimize postharvest losses. Factor six, the capital problem, emphasizes the significance of a lack of sufficient capital (.807) as the predominant barrier. This aligns with broader agricultural research indicating that inadequate capital poses a substantial risk to farm operations. Addressing this challenge requires innovative financial solutions and improved access to credit for small-scale farmers. Factor seven is characterized by the sole presence of inadequate storage facilities (.820) as a barrier. Developing and upgrading storage infrastructure is crucial for mitigating postharvest losses and ensuring food security.

Factor eight (Postharvest losses problem) underscores barriers such as postharvest losses (.884) and a high cost of transportation (.488). These challenges highlight the need for improved postharvest management practices and logistical solutions to minimize losses and enhance market access. Factor nine showed farmers' concern about theft/poaching of farm produce; thus, it highlights the need to address this social menace and the state of insecurity in the study area. Finally, factor ten emphasized poor agronomic practices; thus, it highlights the need for adequate advisory services for the effective dissemination of improved innovative technologies. Furthermore, for factors 1, 2, 3, 4, and 5, respectively, the proportions of farmers that expressed concern were 11.36, 6.82, 5.3, 6.82, and 18.94%, as evidenced by the k-means cluster analysis. Likewise, for factors 6, 7, 8, 9, and 10, respectively, the distributions of farmers that showed concern were 3.03, 15.91, 6.82, 6.82, and 18.18%. A comprehensive understanding of these explicit barriers is vital for policymakers, agricultural extension services, and stakeholders to formulate targeted interventions that address the diverse challenges faced by farmers. By strategically tackling these obstacles, it is possible to create a more resilient, sustainable, and prosperous agricultural sector.

Table 7. Challenges affecting onion production
Tabela 7. Wyzwania wpływające na produkcję cebuli

Constraints	**Mean**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Inadequate knowledge on best agronomic practices	1.84(16)							
Inadequate storage facilities	1.48(20)							.820
High cost of transportation	2.35(14)							
Fluctuation of market price	1.66(17)	–.616						
Lack of sufficient capital	1.52(18)						.807	
Postharvest loses	1.39(19)							
High perishability	1.34(21)					.494		
Disease and insect pest	3.86(1)				.436			.426
Inadequate awareness on the use of postharvest technology	2.83(12)	.622						
Inadequate of technical advice on input usage	3.45(3)		–.416					
Seed viability constraint	3.16(7)		.682					
Climate change constraints	3.36(4)		.715					
Poor infrastructure	2.95(10)					.809		
Inadequate extension services	2.95(9)				–.791			
Difficulty in leasing or rent of farm land	3.18(6)			.596				
Problem of land tenure system	2.36(15)				.552			
High level of illiteracy	3.46(11)							
Theft of produce/ problem of poaching	3.40(5)	.728						
Poor access to market information	3.02(2)			.737				
Low public and private investment	2.52(8)							
Inadequate of incentives to farmers	2.87(13)							
Grand mean (perception index)				2.62(0.4361)				
KCC (Freidman test)				0.201(531.61***)				
Eigen value		1.876	1.697	1.617	1.459	1.38	1.251	1.182
Variance %		8.934	8.08	7.698	6.948	6.571	5.959	5.629
Constraints	F8	F9	F10					
Inadequate knowledge on best agronomic practices			.851					
Inadequate storage facilities								
High cost of transportation	.488							
Fluctuation of market price								

cont. table 7
cd. tab. 7

Constraints	Mean	F1	F2	F3	F4	F5	F6	F7
Lack of sufficient capital								
Postharvest loses	.884							
High perishability								
Disease and insect pest								
Inadequate awareness on the use of postharvest technology								
Inadequate of technical advice on input usage								
Seed viability constraint								
Climate change constraints								
Poor infrastructure								
Inadequate extension services								
Difficulty in leasing or rent of farm land								
Problem of land tenure system								
High level of illiteracy		.766						
Theft of produce/problem of poaching								
Poor access to market information								
Low public and private investment								
Inadequate of incentives to farmers		– .678						
Eigen value	1.176	1.138	1.019					
Variance %	5.599	5.42	4.854					
KMO	0.769							
Bartlett's test of Sphericity	246.38***							

Value in parenthesis in Column 2 are ranks; Mean benchmark is 3.5; Grand mean = sum of mean divided by total number of statements; Perception index = grand mean divided by highest Likert scale value [Sadiq et al. 2018, 2024a].

Source: Source: Field survey, 2023.
Źródło: Badanie terenowe, 2023.

Conclusion and recommendation(s)

Empirically, onion production is a viable enterprise in the study area, and input substitution at various levels of combination is complementary. Moreover, profit significantly influenced the price of the output, as well as the prices of labor, NPK fertilizer, and petrol-engine oil. Likewise, except for the wage rate, the supply of onion output significantly relied on the prices of its output, seeds, NPK fertilizer, and petrol-engine oil. However, the input prices caused a significant decline in the supply of onion output, highlighting the need for realistic incentive measures to address the poor pricing efficiency of these input prices. Nevertheless, the ten challenges, *viz.* poor market information, climate change, low public-private investment, land tenure issues, etc., should be addressed to bolster onion production in the study area.

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