Economic Feasibility of Onion Production under Irrigated Conditions in Gebiresu zone, Afar Region, Ethiopia

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ABSTRACTS

Onion (Allium cepa L.) is one of the most important high-value vegetable crops in Ethiopia, contributing substantially to household income, employment, and agricultural commercialization. This study assessed the economic viability of irrigated onion production in the Gebiresu Zone of the Afar Regional State, Ethiopia. Data were collected from a sample of 200 onion producers selected from the Amibara, Gewane, Haruka, and Gelealo districts using structured questionnaires, key informant interviews, and market price information. Descriptive statistics and economic analysis were employed using SPSS and Microsoft Excel to evaluate production costs, returns, profitability, investment efficiency, and break-even indicators. The results showed that onion production is predominantly managed by male producers (89.5%), while most producers (53%) cultivated more than one hectare, indicating a strong commercial orientation. Furthermore, 51.5% of producers had 10–20 years of farming experience, whereas 10.5% were relatively new entrants. Economically, onion production was highly profitable, generating a gross return of ETB 2,125,000 ha^{-1} and a net return of ETB 1,478,120 ha^{-1}. The benefit–cost ratio (3.28), profitability index (3.28), and return on investment (228.51%) demonstrated strong financial performance. The average yield of 250 qt ha^{-1} substantially exceeded the break-even yield of 76.11 qt ha^{-1}, confirming the economic viability of the enterprise under irrigated conditions. Despite its profitability, onion production was constrained by high marketing costs, which accounted for 38.64% of total costs, as well as rising expenditures on labor and agrochemicals. Therefore, improving market infrastructure and market linkages, promoting efficient input use, strengthening extension and training services for less-experienced producers, and expanding access to rural credit are recommended to reduce production and marketing costs and enhance the profitability and sustainability of irrigated onion production. **Keywords:** Profitability, Production Costs, Gross Returns, Break-Even Yield, Benefit–Cost ratio

INTRODUCTION

Onion (Allium cepa L.) is one of the most widely cultivated and consumed vegetable crops globally (Pareek et al., 2017). Its production spans across various regions due to its adaptability to diverse agro-climatic conditions and its role as a staple ingredient in culinary practices worldwide. In 2020, global onion production reached approximately 104 million metric tons, with major contributions from China, India, and the United States (Jeanneaux, 2023). These countries dominate the global onion market due to their advanced production techniques, efficient irrigation systems, and well-established supply chains. However, despite its global significance, onion production faces challenges such as water scarcity, pests, and post-harvest losses, which often limit productivity and profitability, particularly in developing countries.

In Ethiopia, onion is a high-value crop that contributes significantly to household income and national revenue. The country's onion production has expanded rapidly in recent years, driven by growing domestic demand and export opportunities. Ethiopia produced approximately 371,000 metric tons of onions, cultivated primarily in the Oromia, Amhara, Tigray, and Afar regions (Zegeye, Alemu, Sisay, Mulaw, & Abate, 2024). The crop is highly valued for its role in improving producers ' livelihoods, given its high market demand and profitability compared to other vegetables (A. Nigussie, Y. Kuma, A. Adisu, T. Alemu, & K. J. J. o. H. Desalegn, 2015b). However, challenges such as inadequate access to irrigation, high input costs, and limited market linkages hinder the full exploitation of Ethiopia's onion production potential (Alem, 2008; Hunde, 2017).

In the Gebiresu Zone of the Afar National Regional State, onion production is particularly vital due to the region's irrigated agriculture system and strategic location for market access (Beji, Mulgeta, & Chewaka, 2023). The Awash River provides a reliable water source, enabling year-round onion cultivation. This region contributes significantly to Ethiopia's onion supply, with producers in districts like Amibara, Gewane, Haruka, and Gelealo actively engaged in onion farming (Nigussie et al., 2015b). However, onion production in the Gebiresu Zone is constrained by factors such as inefficient management of irrigation practices (Ayele, Asseffa, & Tuhar, 2023), poor soil fertility management (Nigatu, 2016), and high susceptibility to pests and diseases (Etana, Aga, Fufa, & Healthcare, 2019). Despite these challenges, the region holds immense potential for improving productivity and profitability through targeted interventions in agronomic practices and market development.

Economic analysis of onion production under irrigated conditions is essential for understanding production costs, resource-use efficiency, profitability, and investment attractiveness of onion farming systems (Zhou, 2015). Although onions are one of the most important high-value vegetable crops in Ethiopia, producers operating under irrigation face numerous challenges that can significantly affect economic returns. Rising costs of key production inputs such as seed, fertilizer, labor, irrigation water, fuel, and agrochemicals increase production expenses and may reduce profitability. In addition, market-related constraints, including price fluctuations, weak market linkages, limited market information, postharvest losses, and inadequate storage facilities, often expose producers to substantial income uncertainty. Institutional challenges such as limited access to agricultural credit, insufficient extension support, inadequate irrigation infrastructure, and weak producer organizations further constrain production efficiency and commercialization. These interrelated economic, market, and institutional factors can undermine the sustainability and competitiveness of onion production despite the favorable agroecological conditions and growing market demand. Consequently, a comprehensive economic assessment is needed to quantify production costs and returns, evaluate profitability indicators, and identify the key constraints affecting the economic performance of onion farming under irrigated conditions. Therefore, this study was conducted to evaluate the economic performance of onion production under irrigation in the Gebiresu Zone of the Afar National Regional State, Ethiopia, and to generate evidence-based recommendations for improving producer profitability, resource-use efficiency, and market competitiveness.

MATERIAL AND METHODS

1.1 Study Area

The study was conducted during the 2024/25 cropping season in four major onion-producing districts of the Gebiresu Zone, Afar National Regional State, Ethiopia, namely Amibara, Gewane, Haruka, and Gelealo districts. The zone is located within the Middle Awash River Basin and is characterized by an arid to semi-arid climate with extensive irrigation-based agricultural production systems. The availability of irrigation water from the Awash River enables year-round cultivation of high-value vegetable crops, particularly onion. These districts were purposively selected because of their substantial contribution to regional onion production, high concentration of irrigated agriculture, and accessibility for data collection.

1.2 Research Design

A cross-sectional survey research design was employed to assess the economic feasibility of onion production under irrigated conditions. The study combined quantitative and qualitative approaches to collect information on production costs, returns, profitability indicators, and production and marketing practices of onion producers.

1.3 Sampling Design and Sample Size Determination

1.3.1 Sampling Frame and Sampling Unit

The sampling frame consisted of all onion-producing households registered by the respective District Offices of Agriculture in Amibara, Gewane, Haruka, and Gelealo districts during the 2024/25 production season. The sampling unit was an individual onion-producing household.

1.3.2 Sampling Procedure

A multistage sampling technique was employed. In the first stage, four districts (Amibara, Gewane, Haruka, and Gelealo) were purposively selected due to their importance in irrigated onion production. In the second stage, major onion-producing kebeles were identified in consultation with district agricultural experts. In the third stage, onion-producing households were selected using simple random sampling from the producer lists obtained from the respective district agricultural offices.

1.3.3 Sample Size Determination

The sample size was determined using the formula:

$$n = \frac{N}{[1 + N(e^2)]} \tag{1}$$

where:

n = required sample size

N = total number of onion-producing households in the study area

e = level of precision (0.05)

Based on the sampling frame and available resources, a total sample of 200 onion-producing households was selected. Fifty households were randomly selected from each of the four districts, resulting in a total sample size of 200 respondents. The sample distribution was as follows: Amibara District = 50 households, Gewane District = 50 households, Haruka District = 50 households, and Gelealo District = 50 households a total = 200 households.

1.4 Data Collection Methods

1.4.1 Types and Sources of Data

Both primary and secondary data were used in this study. Primary data were collected from sampled onion-producing households through structured questionnaires and face-to-face interviews. Information collected included: Demographic characteristics, Farm size and land allocation, Production practices, Input utilization, Labor use, Irrigation management, Production costs, Marketing costs, and Yield and revenue information.

Secondary data were obtained from: District Offices of Pastoral and Agro-pastoral, published reports, Journal articles, and Relevant government documents.

1.4.2 Data Collection Instruments

A structured questionnaire was designed, pre-tested, and administered through face-to-face interviews with sampled onion producers. The questionnaire was developed to obtain detailed information on socioeconomic characteristics, production costs, output levels, marketing activities, and profitability indicators.

1.5 Data Analysis Methods

The collected data were coded, entered, and analyzed using Microsoft Excel and Statistical Package for Social Sciences (SPSS) software.

1.5.1 Descriptive Statistical Analysis

Descriptive statistics, including means, percentages, frequencies, standard deviations, minimum values, and maximum values, were employed to summarize socioeconomic characteristics and economic performance indicators.

Mean:

$$\text{Mean} = \frac{\Sigma X}{N} \tag{2}$$

Standard Deviation:

$$\text{Std. Deviation} = \frac{\sqrt{[\Sigma(X - \bar{X})^2}}{N - 1} \tag{3}$$

Percentage:

$$\text{Percentage (\%)} = \left(\frac{\text{Number of respondents in a category}}{\text{Total number of respondents}}\right) \times 100 \tag{4}$$

Relative Frequency:

$$\text{Relative Frequency} = \frac{\text{Frequency for a Category}}{\text{Total Responses}} \tag{5}$$

1.5.2 Weighted Average Frequency Analysis

Weighted Average Frequency (WAF) was employed to rank the relative importance of production and marketing cost components and other economic variables.

The weighted average frequency was calculated as:

$$\text{WAF} = \frac{(\text{Fi} \times \text{Wi})}{\Sigma \text{Wi}} \tag{6}$$

Where:

Fi = frequency of responses

Wi = assigned weight

Higher WAF values indicate greater relative importance of a variable.

1.5.3 Economic Analysis

i. Land Cost Estimation

Land cost was estimated based on prevailing rental values and opportunity costs of land use.

$$\text{Land Input Cost } (ETB/ha) = \text{Area of Land } \times \text{Rental Cost} \tag{7}$$

ii. Labor Cost Estimation

Labor cost was calculated by summing labor expenses incurred during land preparation, planting, irrigation, weeding, harvesting, and postharvest handling

$$\text{Labor Cost (ETB/ha)} = \sum(\text{Labor Days} \times \text{Daily Wage Rate}) \tag{8}$$

iii. Marketing Cost Estimation

Marketing costs included transportation, packaging, loading and unloading, brokerage, and storage costs.

$$\text{Marketing Cost (ETB)} = \text{Transportation } + \text{Brokerage } + \text{Packaging } + \text{Brokerage} + \text{Storage Cost} \tag{9}$$

iv. Gross Return

Gross returns were calculated using the yield and the prevailing market price. The gross returns were determined using the formula:

$$\text{Gross Returns (ETB)} = \text{Total Yield (qt/ha)} \times \text{Market Price (ETB/qt)} \tag{10}$$

v. Total Cost of Production

The total production cost was calculated by summing the costs of land, labor, input, and marketing. The total production cost was determined using the formula:

$$\text{Total Cost (ETB/ha)} = \text{Land Cost} + \text{Input Cost} + \text{Labor Cost} + \text{Marketing Cost} \tag{11}$$

vi. Net Returns

Net returns were calculated as the difference between gross returns and total production costs. Net returns were determined using the formula:

$$\text{Net Returns (ETB/ha)} = \text{Gross Returns} - \text{Total Cost} \tag{12}$$

vii. Input-Output Ratio

The Input-Output Ratio was used to measure the efficiency of resource use by comparing total inputs to output The Input-Output Ratio was determined using the formula:

$$\text{Input} - \text{Output Ratio} = \frac{\text{Gross Returns}}{\text{Total cost}} \tag{13}$$

viii. Benefit-Cost- Ratio

The Benefit-Cost-Ratio was used to compare the total benefits and costs in order to determine the economic viability of onion production. It was calculated using the formula:

$$\text{Benefit} - \text{Cost Ratio (BCR)} = \frac{\text{Gross Return}}{\text{Total cost}} \tag{14}$$

A BCR greater than one indicates economic feasibility.

ix. Break-Even Analysis

The break-even yield was calculated as the minimum yield required to cover production costs. The break-even yield was determined using the following formula:

$$\text{Break} - \text{Even Yield (qt/ha)} = \frac{\text{Total Cost (ETB/ha)}}{\text{Market Price (ETB/qt)}} \tag{15}$$

x. Return on Investment (ROI)

Return on Investment (ROI) was calculated to measure the profitability of onion production relative to its costs. It was determined using the following formula:

$$\text{ROI (\%)} = \left(\frac{\text{Net Return}}{\text{Total Cost}}\right) \times 100 \tag{16}$$

xi. Gross Margin (GM)

Gross Margin measures the profitability of an enterprise after accounting for variable costs.

$$\text{Gross Margin (ETB ha}^{-1}) = \text{Gross Revenue } - \text{Total Variable Cost} \tag{17}$$

xii. Profit Margin (PM)

Profit Margin indicates the proportion of revenue retained as profit after covering all production costs.

$$\text{Profit Margin (\%)} = \left(\frac{\text{Net Return (ETB ha}^{-1})}{\text{Gross Revenue (ETB ha}^{-1})}\right) \times 100 \tag{18}$$

xiii. Labor Productivity (LP)

Labor Productivity measures the output or income generated per unit of labor employed.

Revenue-based

$$\text{Labor Productivity} = \left(\frac{\text{Gross Revenue (ETB)}}{\text{Total Labor Used (person} - \text{days)}}\right) \tag{19}$$

Output-based

$$\text{Labor Productivity} = \left(\frac{\text{Total Yield (kg or t ha}^{-1})}{\text{Total Labor Used (person}-\text{days)}}\right) \tag{20}$$

xiv. Profitability Index (PI)

Profitability Index evaluates the return generated per unit of investment.

$$\text{Profitability Index} = \left(\frac{\text{Net Return (ETB)}}{\text{Total Production Cost (ETB)}}\right) \tag{21}$$

xv. Break-Even Price (BEP)

Break-Even Price is the minimum selling price required to cover total production costs.

$$\text{Break} - \text{Even Price (ETB kg}^{-1}) = \left(\frac{\text{Total Cost of Production (ETB ha}^{-1})}{\text{Total Yield (kg ha}^{-1})}\right) \tag{22}$$

xvi. Margin of Safety (MOS)

Margin of Safety measures how much actual sales exceed the break-even sales level.

$$\text{Margin of Safety (\%)} = \left(\frac{\text{Actual Sales Revenue} - \text{Break–Even Sales Revenue}}{\text{Actual Sales Revenue}}\right) \times 100 \quad (23)$$

xvii. Payback Period (PP)

Payback Period estimates the time required to recover the initial investment from net cash inflows.

$$\text{Payback Period (years)} = \left(\frac{\text{Initial Investment Cost (ETB)}}{\text{Annual Net Cash Flow (ETB year}^{-1})}\right) \quad (24)$$

RESULTS AND DISCUSSION

1.6 Demographic characteristics

The demographic profile of onion producers in the Gebiresu Zone, covering the districts of Amibara, Gelealo, Haruka, and Gewane, particularly regarding gender, education level, family size, and age of respondents (N=200), was presented in Figure 1. These factors can have significant implications for farm management practices, labor availability, decision-making, and overall productivity.

1.6.1 Gender of Household

Figure 1 shows that the majority of respondents were male (89.5%), while females accounted for only 10.5% of the sampled households. The high male representation suggests that onion farming in the study area is predominantly male-dominated, likely reflecting traditional gender roles in agricultural activities (Devi, Buechler, & Food Security. Practical Action, 2009). Male-headed households are often associated with better access to resources, including land and capital, as compared to female-headed households, which could influence farm productivity (Githinji, Konstantinidis, & Barenberg, 2011).

1.6.2 Education

The education levels of respondents were diverse, with 26.5% of respondents being illiterate and 24.5% having attained education beyond grade 12. High school and elementary school graduates accounted for 20.5% and 15%, respectively. The highest percentage of literate respondents (32%) was observed in Gelealo district, while Gewane had the highest proportion of illiterate respondents (32%).

Education plays a pivotal role in the adoption of improved farming practices and technology (Admassie & Ayele, 2010). Producers with higher education levels are more likely to implement efficient resource use, manage production risks, and access market information. For instance, Gewane's relatively high illiteracy rate may hinder the adoption of innovative practices, potentially affecting productivity and profitability.

1.6.3 Family Size

The majority of households (73.5%) had small family sizes of 1 to 3 members. Households with larger family sizes of 4 to 6 and above 6 accounted for 14% and 12.5%, respectively. Gelealo district reported the highest proportion of small family sizes (84%), while Amibara had the highest proportion of larger families (28%).

Family size is a critical determinant of household labor availability (Bedemo, Getnet, & Kassa, 2013). Smaller households may face labor constraints, especially during labor-intensive periods like planting and harvesting (Nolte & Ostermeier, 2017). This could result in higher reliance on hired labor, thereby increasing production costs. On the other hand, larger families could reduce labor costs but may increase household consumption needs, potentially affecting the allocation of income to farm inputs (Cornia, 1985).

1.6.4 Age of Respondents

The age distribution of respondents showed that 71% were within the economically active age group of 25 to 40 years. Respondents aged 41 to 60 and 61 to 80 constituted 19.5% and 9.5%, respectively. Haruka had the highest proportion of respondents aged 25 to 40 (82%), while Amibara had the largest proportion of respondents aged 61 to 80 (16%).

Younger producers are generally more energetic, innovative, and willing to adopt new farming techniques, which can enhance productivity (Kale et al., 2024).

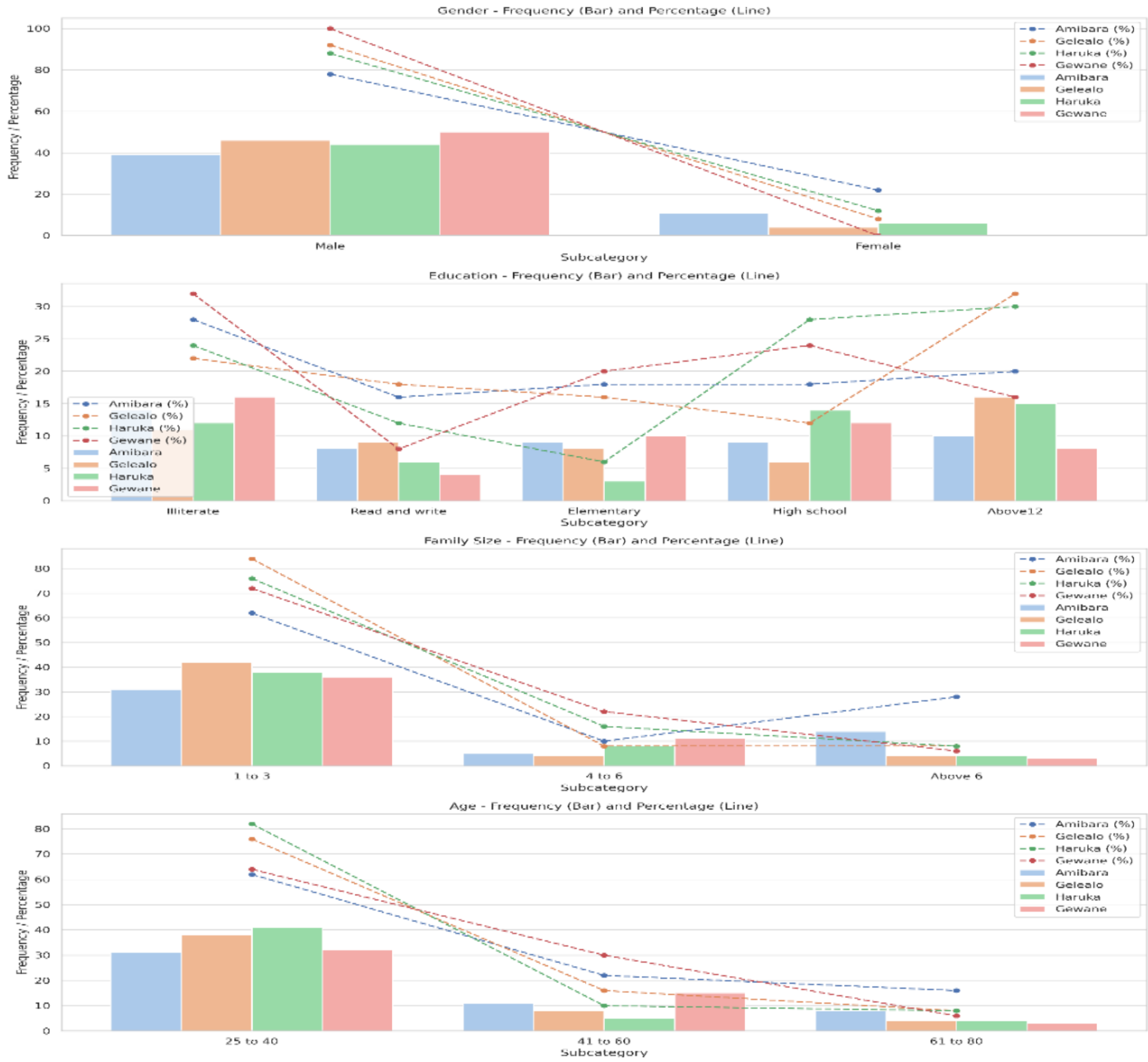

Figure 1: Demographic profile of the study area Across Districts (N=200)

1.7 Land holding and experience in onion seed production

The data in Figure 2 provides a detailed breakdown of onion seed farming experience across the districts of Amibara, Gelealo, Haruka, and Gewane in Gebiresu Zone. The data provides critical insights into resource utilization, production expertise, and their implications for the economic performance of onion seed farming.

1.7.1 Land Allocated for Onion Bulb Production

Figure 2 shows that 53% of respondents allocated more than 1 hectare of land for onion bulb production, while only 0.5% allocated less than 0.25 hectares. Most respondents (23.5%) allocated between 0.75 and 1 hectares, while smaller portions of land (0.25–0.5 and >0.5–0.75 hectares) accounted for 8% and 15%, respectively. Gewane had the highest proportion of respondents allocating over 1 hectare (62%), followed by Gelealo (58%).

The significant land allocation for onion production indicates the economic importance of the crop in the study area. Producers who allocate larger lands are likely commercial producers with higher production and income potential (Embaye et al., 2018).

The higher allocation of land in Gewane and Gelealo suggests that these districts are more engaged in commercial onion production. This could be attributed to better access to irrigation facilities, favorable agro-climatic conditions, or market access, which are critical for profitable onion farming (Boru, Birhan, & Beyene, 2024).

1.7.2 Experience in Onion Bulb Production

The respondents' farming experience ranged from less than 10 years to over 30 years, with no respondents reporting experience beyond 30 years. The majority of producers (51.5%) had 10 to 20 years of experience, followed by 22% with less than 10 years and 16% with 20 to 30 years. Only 10.5% of respondents reported no prior experience in onion bulb farming. Haruka had the highest proportion of producers with 10 to 20 years of experience (66%), while Gelealo had the highest proportion of respondents with no prior experience (14%).

Farming experience is directly linked to productivity and profitability in agriculture (Bwala & John, 2018). A producer with 10 to 20 years of experience is likely more skilled at implementing best practices, managing resources efficiently, and responding to production challenges. These advantages can contribute to higher yields and reduced production costs (Fischer & Connor, 2018).

The 10.5% of producers with no prior experience may face challenges such as inadequate knowledge of irrigation management, pest control, and market access. This lack of experience could lead to lower yields and higher production risks, particularly in districts like Gelealo, where 14% of respondents reported no farming experience. Providing targeted extension services and training programs could help address these challenges and enhance productivity for less experienced producers (Yeshiwas, Alemayehu, & Adgo, 2023).

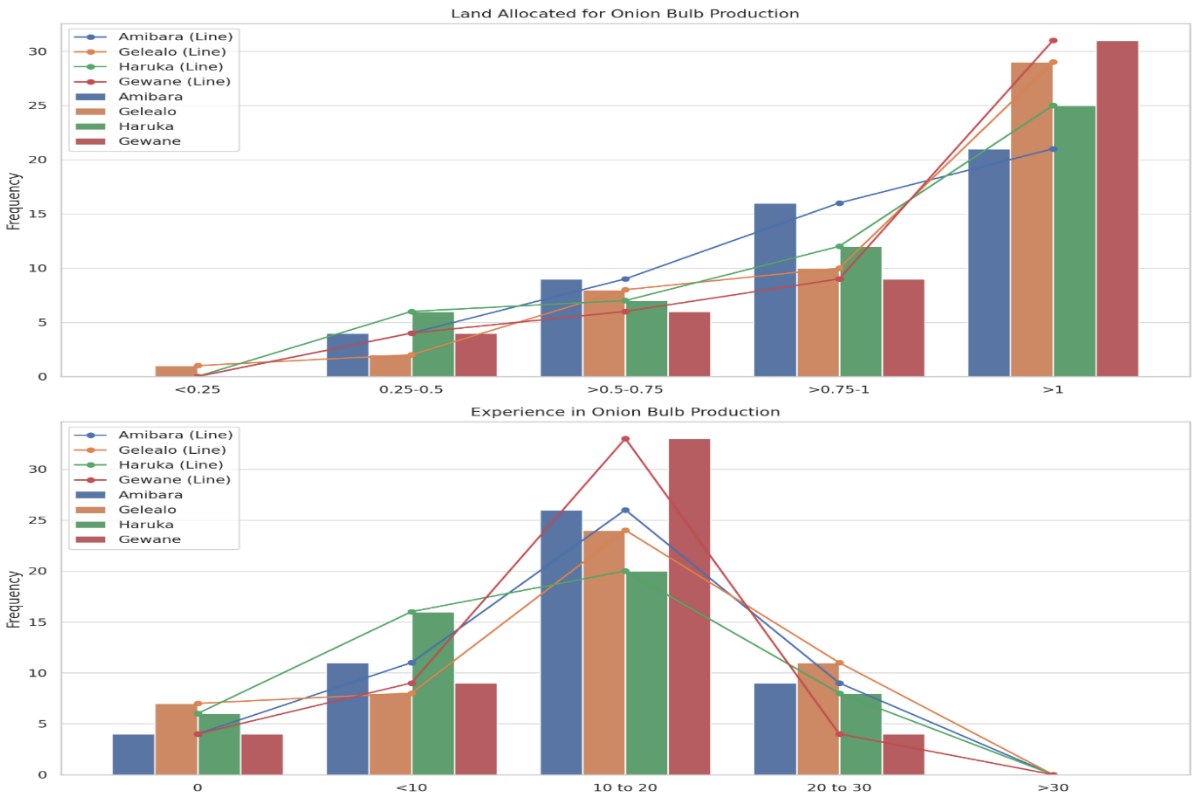

Figure 2: Distribution of Land Allocation and Experience in Onion Bulb Production Across Districts (N=200) (Bar represents Frequency and Lines represent the Percentage)

1.8 Economic Analysis of Onion Production

The economic analysis of onion production under irrigated conditions revealed a total production and marketing cost of 646,880 ETB ha^{-1} (Table 1). The distribution of costs among production and marketing activities showed substantial variation, indicating that profitability is strongly influenced by a few major cost components. Marketing expenses constituted the largest share of total costs, followed by chemical management, labor, fertilizer, land inputs, post-harvest handling, seed, and irrigation costs (Figure 3). Understanding the relative contribution of these components is essential for identifying opportunities to improve production efficiency and profitability.

1.8.1 Marketing Costs

Marketing costs represented the largest expenditure category, accounting for 250,000 ETB ha^{-1} (38.64%) of the total production cost. These expenses include broker commissions, transportation, loading and unloading, packaging, and other transaction-related charges incurred during the marketing process. The predominance of marketing costs indicates that a substantial portion of the value generated from onion production is absorbed after harvest rather than during cultivation. Such high marketing expenses reduce producers' profit margins and limit the economic benefits derived from production. The result suggests inefficiencies in the marketing system, including dependence on intermediaries, inadequate market infrastructure, and limited direct access to consumers. The disproportionate share of marketing costs highlights systemic challenges within the agricultural value chain, which can erode profitability despite favorable yields (German, Bonanno, Foster, & Cotula, 2020). The dependency on brokers significantly diminishes producers' profit margins, as producers often lack adequate bargaining power to negotiate favorable prices (Ryall & Sorenson, 2007). Furthermore, high transportation costs remain a critical issue, often stemming from inadequate infrastructure in rural areas (Booth, Hanmer, & Lovell, 2000). Improving producer cooperatives, strengthening market linkages, and enhancing transportation infrastructure could substantially reduce marketing costs and increase farm profitability. Studies indicate that cooperative structures enable producers to pool resources, negotiate better prices, and enhance their share of the final consumer price (Sykuta & Cook, 2001).

1.8.2 Chemical Costs

Chemical management constituted the second-largest cost component, amounting to 90,000 ETB ha^{-1} (13.92%). These expenses primarily involve the purchase and application of pesticides, fungicides, and other crop protection chemicals used to manage pests and diseases. The relatively high share of chemical costs reflects the importance of maintaining crop health under irrigated production systems, where favorable growing conditions may also encourage pest and disease development. While chemical inputs contribute significantly to yield protection and productivity, excessive reliance on them can increase production costs and create environmental concerns. Overuse or improper application of pesticides and fertilizers can lead to significant environmental risks, such as soil degradation, water contamination, and reduced biodiversity (Hossain, Shahrukh, & Hossain, 2022). Adoption of integrated pest management (IPM) practices could reduce input costs while maintaining effective pest control and environmental sustainability. Evidence suggests that IPM can enhance long-term productivity while minimizing negative externalities (Becker & policymakers, 2017).

1.8.3 Labor Costs

Labor costs accounted for 76,000 ETB ha^{-1} (11.75%) of the total production cost, making labor the third-largest expenditure category. Onion production requires considerable manual labor for activities such as nursery management, transplanting, weeding, irrigation management, harvesting, and post-harvest handling. The substantial labor requirement reflects the labor-intensive nature of onion cultivation under smallholder production systems. Rising wage rates and seasonal labor shortages may further increase production expenses and reduce profitability. Rising rural wage rates and seasonal labor shortages further constrain profitability, especially during peak farming periods (Fink, Jack, & Masiye, 2020). Mechanization of selected operations, particularly planting and weeding, could improve labor efficiency and reduce production costs. Studies have demonstrated that mechanization not only reduces labor costs but also enhances efficiency and productivity in onion farming (Khanpara, Mehta, & Bharad, 2024).

1.8.4 Fertilizer Costs

Fertilizer costs represented 60,000 ETB ha^{-1} (9.28%) of total production expenses. These costs include expenditures on UREA and DAP fertilizers used to improve soil fertility and support crop growth. Adequate nutrient management is essential for achieving high onion yields and maintaining soil productivity. However, increasing fertilizer prices and inefficient application practices can significantly affect production profitability. The result highlights the importance of adopting soil-test-based fertilizer recommendations and site-specific nutrient management strategies to maximize fertilizer use efficiency while minimizing unnecessary expenditures.

1.8.5 Land Rental and Preparation Costs

Land inputs, comprising land rental and land preparation costs, amounted to 50,000 ETB ha^{-1} (7.73%). These expenses encompass essential activities such as land clearance, plowing, and canal preparation, all of which are critical for establishing a suitable environment for optimal onion growth. The relatively moderate share of land-related costs suggests that land access is relatively affordable in the study area, likely due to the prevalence of irrigation-supported farming systems. These systems mitigate risks associated with rainfed agriculture, making land use more efficient and predictable. However, land rental and preparation costs can still pose a barrier for resource-constrained producers, limiting their ability to engage in onion farming at a commercial scale (Hillenbrand, 2022).

1.8.6 Post-Harvest and Storage Costs

Post-harvest handling and storage costs also accounted for 50,000 ETB ha^{-1} (7.73%) of total expenditure. These costs include harvesting, sorting, grading, cleaning, packaging, temporary storage, and handling operations before marketing. Effective post-harvest management is critical for maintaining bulb quality and reducing losses during storage and transportation. The observed expenditure highlights the importance of proper handling practices and improved storage facilities. Investment in improved storage technologies could reduce post-harvest losses and enhance marketable yield, thereby improving profitability. Such facilities can significantly reduce spoilage and extend the shelf life of onions, thereby enhancing marketability and profitability (Ilyas, 2010). Despite its importance, inadequate storage infrastructure remains a significant challenge, often resulting in high post-harvest losses that reduce the economic value of onions. Poor ventilation, improper handling, and a lack of cold storage facilities contribute to these losses, particularly in warm and humid climates (Kiaya, 2014). Furthermore, training producers in proper post-harvest handling techniques, including sorting, grading, and packaging, can further improve the quality and market appeal of the produce (Osei-Kwarteng, Ogwu, Mahunu, & Afoakwah, 2024).

1.8.7 Seed Costs

Seed costs accounted for 36,880 ETB ha^{-1} (5.70%) of total production costs. Although relatively small compared with other cost components, seed quality plays a crucial role in determining crop establishment, plant vigor, and final yield. The use of certified and high-quality seed contributes to improved germination, uniform crop growth, and enhanced productivity. Therefore, maintaining access to quality seed remains essential despite its relatively modest contribution to total production costs.

1.8.8 Irrigation Costs

Irrigation costs represented the smallest expenditure category, amounting to 34,000 ETB ha^{-1} (5.26%). These costs include water application, irrigation infrastructure maintenance, and related operational expenses. The relatively low share of irrigation costs indicates efficient utilization of irrigation resources within the production system. Nevertheless, irrigation remains a critical component of onion production in arid and semi-arid environments, where crop growth depends heavily on a reliable water supply. Improving irrigation efficiency through better scheduling and water management practices could further enhance resource use efficiency and productivity.

Table 5: Production and Marketing Cost Structure of Onion Production under Irrigated Conditions (ETB ha^{-1})

Component	**Cost (ETB** ha^{-1}**)**
Land Inputs (Rental + Prep)	50,000
Seed Rate	36,880
Irrigation	34,000
Fertilizer (UREA + DAP)	60,000
Labor (Planting + Weeding)	76,000
Chemical Management	90,000
Post-Harvest + Storage	50,000
Marketing (Broker)	250,000
Total Production Cost	**646,880**

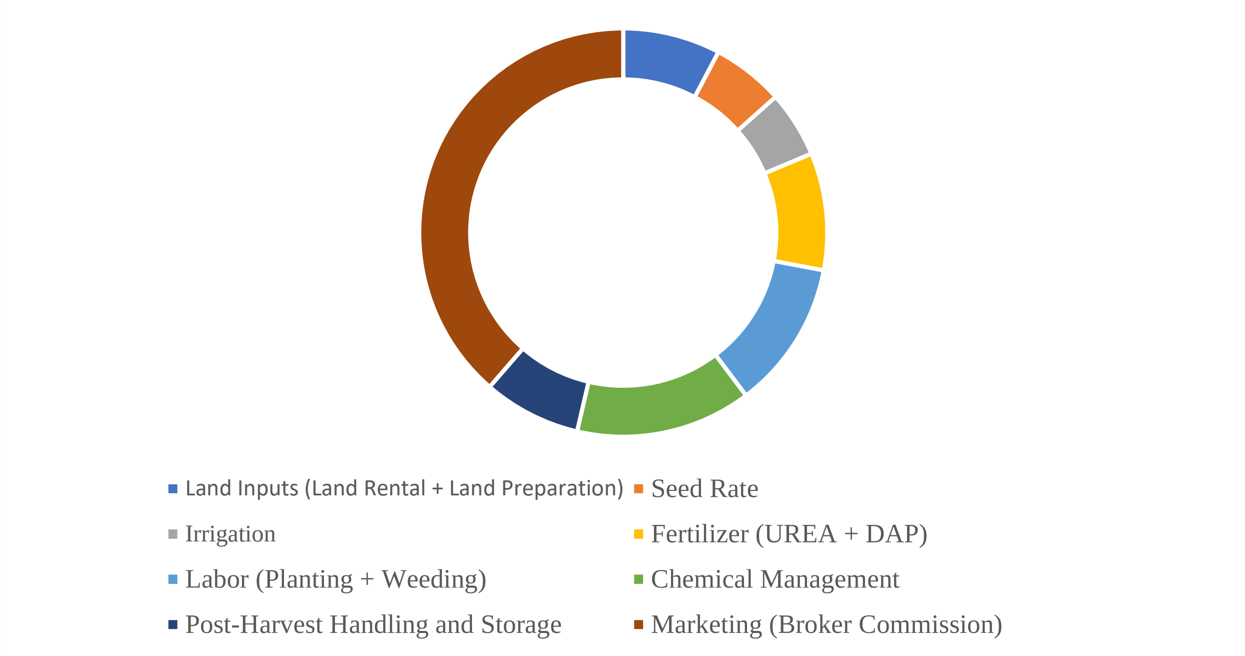

Figure 3 Percentage Contribution of Major Production and Marketing Cost Components to Total Production Cost

1.9 Economic Performance of Onion Production under Irrigated Conditions

The analysis of returns and profitability, as presented in Table 2, provides valuable insights into the financial viability of onion production under irrigated conditions in the Gebiresu Zone. Key indicators such as gross returns, net returns, input–output ratio, break-even yield, and return on investment (ROI) highlight the economic performance of onion farming and demonstrate its potential as a profitable agricultural enterprise.

1.9.1 Gross Returns

Gross return represents the total revenue generated from onion sales before deducting production and marketing costs. The study revealed that onion producers obtained a **gross return of ETB 1,120,000 ha^{-1}**, derived from an average yield of **28 t ha^{-1}** and a farm-gate selling price of **ETB 40 kg^{-1}.** This high gross return indicates the strong income-generating potential of irrigated onion production and reflects favorable market demand coupled with satisfactory productivity levels. The result suggests that onion cultivation can serve as an important source of cash income for farming households. To sustain and potentially increase gross returns, producers should prioritize maintaining high-quality standards to command premium prices in the market. This includes adhering to best practices in harvesting, grading, and packaging (Kitinoja & Kader, 2002). Additionally, strengthening market linkages and diversifying sales channels, such as entering export markets or participating in cooperative marketing initiatives, can enhance revenue streams and reduce market dependency (Ferris et al., 2014).

1.9.2 Net Returns

Net return measures the profit remaining after deducting all production and marketing costs from gross revenue. The analysis showed that onion producers earned a **net return of ETB 473,120 ha^{-1}**, indicating that nearly half a million birrs was generated as profit per hectare. The positive and substantial net return demonstrates that onion production is financially rewarding and capable of significantly improving household income. The magnitude of the net return also suggests that the enterprise can withstand moderate fluctuations in market prices or production costs while remaining profitable. The significant net returns reflect the economic viability of onion production, driven by efficient production practices, favorable market prices, and the cultivation of high-value crops under irrigated conditions. However, future profitability could be threatened by rising input costs, market volatility, and inefficiencies in the value chain. For instance, factors such as increasing costs for fertilizers, pesticides, and labor, as well as fluctuating market prices due to seasonality and demand dynamics, may reduce margins (Bowman, Zilberman, & society, 2013).

1.9.3 Benefit-Cost Ratio (BCR)

The **Benefit-Cost Ratio (BCR)** was estimated at **1.73**, indicating that every **ETB 1.00** invested in onion production generated **ETB 1.73** in return. In other words, producers obtained a net gain of **ETB 0.73** for every birr invested. Since a BCR greater than one signifies economic feasibility, the obtained value confirms that onion production under irrigated conditions is a profitable and financially viable enterprise. The relatively high BCR further indicates efficient utilization of production resources and a favorable return on investment. A BCR greater than 1.0 is widely considered a strong indicator of economic feasibility, demonstrating that the benefits of onion production outweigh the costs (Panancheri, 2023). The high BCR in the Gebiresu Zone of the Afar region reflects the profitability of onion farming under irrigated conditions, where favorable yields, competitive market prices, and efficient resource utilization contribute to the economic viability of the enterprise. The BCR highlights the capacity of onion farming to generate sufficient returns to cover both fixed and variable costs, providing a robust economic foundation for producers. However, external factors, such as market price volatility, rising input costs, and climate variability, could potentially undermine future profitability (Batten, 2018).

1.9.4 Gross Margin

Gross margin, calculated as the difference between gross return and total variable cost, was **ETB 473,120 ha^{-1}.** The positive gross margin indicates that onion production generated sufficient revenue to cover all variable expenses and still provide a considerable surplus to producers. This finding confirms the economic efficiency of onion production under irrigation and highlights its contribution to farm profitability. Similar findings were reported by (A. Nigussie, Y. Kuma, A. Adisu, T. Alemu, & K.

Desalegn, 2015a), who found that onion production generated substantial gross margins under smallholder irrigation schemes in Ethiopia.

1.9.5 Production Cost per Kilogram

The average **production cost per kilogram of onion was ETB 23.1,** whereas the average selling price was **ETB 40 kg^{-1}.** This implies a price-cost margin of **ETB 16.9 kg^{-1},** demonstrating that producers received a substantial return above production costs for every kilogram sold. The relatively low unit production cost compared with the market price indicates efficient production practices and favorable economic performance (Beshir & Nishikawa, 2012; Nigussie et al., 2015a).

1.9.6 Profit Margin

The **profit margin was 42.24%,** indicating that approximately **42% of total revenue remained as profit** after covering all production and marketing expenses. A profit margin exceeding 40% reflects strong financial performance and suggests that onion production provides attractive returns to producers. Such a high margin enhances the enterprise's resilience against production risks and market uncertainties. This finding is consistent with previous studies that identified onion as one of the most profitable vegetable crops under irrigated production systems (Nigussie et al., 2015a).

1.9.7 Labor Productivity

Labor productivity was estimated at **ETB 250 Labor Day^{-1}**, indicating that each laborer employed in onion production generated ETB 250 in economic returns. This finding demonstrates the contribution of onion production to rural employment and income generation. The positive labor productivity also suggests that labor resources were utilized efficiently throughout production, harvesting, and marketing activities. Similar findings have been reported in studies of irrigated vegetable production in Ethiopia and other developing countries, where onion cultivation was found to generate substantial returns to labor due to its labor-intensive nature and relatively high market value (Fikadu, 2022).

Table 6 Economic Performance Indicators of Onion Production under Irrigated Conditions

Indicator	Unit	Value
Total Production and Marketing Cost	ETB ha^{-1}	646,880
Average Yield	t ha^{-1}	28
Farm-Gate Selling Price	ETB kg^{-1}	40
Gross Revenue (Gross Return)	ETB ha^{-1}	1,120,000
Total Variable Cost (TVC)	ETB ha^{-1}	646,880
Gross Margin	ETB ha^{-1}	473,120
Net Return (Net Profit)	ETB ha^{-1}	473,120
Production Cost per Kilogram	ETB kg^{-1}	23.1

Gross Return per Birr Invested	ETB ETB^{-1}	1.73
Benefit-Cost Ratio (BCR)	Ratio	1.73
Profit Margin	%	42.24
Labor Productivity	ETB Labor Day^{-1}	250

1.10 Economic Feasibility and Investment Attractiveness of Onion Production

The economic feasibility analysis provides a comprehensive assessment of the financial viability, risk-bearing capacity, and investment attractiveness of onion production under irrigated conditions. The results indicate that onion production is not only profitable but also economically resilient and attractive for both smallholder farmers and potential agricultural investors.

1.10.1 Input-Output Ratio

The input-output ratio of 1.73 indicates that for every 1 ETB invested in production, producers generate 1.73 ETB ha -1 in returns. This ratio highlights the high efficiency of resource utilization in onion farming, reflecting the effective deployment of land, labor, and inputs to maximize economic returns. A high input-output ratio signifies that production resources are being efficiently transformed into outputs, ensuring profitability and sustainability. Onion farming under irrigated conditions benefits from controlled water availability, reduced production risks, and the adoption of optimized farming practices, which collectively contribute to high productivity (Khan, Hassan, Shahriyar, & Computing, 2023). To sustain and further improve this level of efficiency, continued investment in irrigation systems and precision farming technologies is crucial. Policymakers and agricultural development programs should focus on promoting access to affordable inputs, including quality seeds, fertilizers, and pest management solutions, as well as providing support for irrigation infrastructure (Namara et al., 2010).

1.10.2 Break-Even Yield

The **break-even yield was estimated at 16.17 t ha^{-1},** meaning that producers must harvest at least 16.17 tonnes of onion per hectare to cover all production costs without incurring losses. Since the actual average yield was **28 t ha^{-1},** producers achieved approximately **73% higher yield than the break-even requirement.** This considerable difference indicates a strong production buffer and suggests that onion production can remain profitable even if yields decline due to unfavorable weather, pest infestations, or other production constraints. As long as producers achieve the break-even yield, they can cover their production costs and avoid financial losses, ensuring the sustainability of their farming operations (Atoyebi, Bello, & Owolarafe, 2022).

1.10.3 Return on Investment (ROI)

The Return on Investment (ROI) was 73.14%, implying that producers earned a profit equivalent to approximately 73% of their total investment. ROI is one of the most important indicators of investment performance because it measures the efficiency with which invested capital generates profits. An ROI exceeding 70% is considered highly attractive in agricultural enterprises, indicating that onion production offers substantial financial rewards relative to the capital employed. This high ROI enhances the competitiveness of onion production compared with many alternative agricultural investments. These variables can significantly affect profitability and need to be managed effectively to sustain high returns (Ailawadi, Farris, & Parry, 1999). To maintain or enhance ROI, producers should prioritize strategies for cost minimization and yield optimization. This can include adopting efficient farming practices such as integrated pest management (IPM) and precision agriculture to reduce input costs while maximizing productivity (Kebe et al., 2023).

1.10.4 Profitability Index (PI)

The Profitability Index (PI) was 1.73, which is identical to the BCR because the analysis was conducted for a single production cycle. A PI greater than one indicates that the present value of benefits exceeds the value of costs incurred. The obtained value suggests that onion production creates significant economic value and provides returns substantially above investment costs. Therefore, the enterprise can be categorized as economically attractive and financially efficient. Profitability indicators exceeding unity are commonly used to identify profitable agricultural enterprises capable of generating sustainable returns on invested capital (Zorn, Esteves, Baur, & Lips, 2018).

1.10.5 Break-Even Price

The **break-even price was** ETB **23.1 kg^{-1},** indicating that producers need to sell onion at a minimum price of ETB 23.1 per kilogram to recover production costs. Given the actual average selling price of **ETB 40 kg^{-1},** producers enjoyed a price advantage of **ETB 16.9 kg^{-1}** above the break-even level. This substantial margin demonstrates strong market competitiveness and indicates that onion production can remain profitable even under moderate market price declines. Similar findings have been reported in studies of irrigated vegetable production, where actual market prices significantly exceeded break-even prices, thereby providing producers with a considerable buffer against market volatility and production risks (Fadairo, Atser, Ver, Akombo, & Ikuemonisan, 2026).

1.10.6 Margin of Safety

The **margin of safety in yield (42.24%)** and **margin of safety in price (42.25%)** provide important measures of financial risk and enterprise stability. These indicators imply that yield or market price could decline by approximately **42% before the enterprise reaches the break-even point.** The relatively large margins of safety indicate a low level of financial vulnerability and demonstrate that onion production is highly resilient to production and market shocks. Such risk-buffering capacity is particularly important in agricultural systems where fluctuations in weather, pests, diseases, and market prices are common. Similar observations have been reported in agricultural investment and farm management studies, where larger margins of safety were associated with greater enterprise resilience and reduced financial risk (Watson, Armerin, Klinger, & Belton, 2018).

1.10.7 Payback Period

The **payback period was estimated at 1.37 production seasons,** indicating that the initial investment can be recovered within slightly more than one production cycle. A short payback period is generally viewed as a desirable investment characteristic because it reduces financial risk and improves capital turnover. The result suggests that onion production enables producers to recoup their investment rapidly and generate profits within a relatively short period. This finding is consistent with agricultural investment appraisal literature, which identifies shorter payback periods as indicators of lower investment risk and greater financial attractiveness (Ruales, Seriño, Ratilla, Cuizon, & Enerlan, 2020).

1.10.8 Investment Attractiveness

Based on the combined performance of profitability, investment efficiency, risk tolerance, and capital recovery indicators, the overall **investment attractiveness of onion production was rated as high.** The high gross revenue, substantial net return, favorable BCR and PI, strong ROI, large margins of safety, and short payback period collectively indicate that onion production under irrigated conditions is a financially sound and economically attractive enterprise. This finding is consistent with previous studies demonstrating that irrigated horticultural crops, particularly onion, offer superior economic returns and investment opportunities compared with many traditional agricultural enterprises (Absanto, Mkunda, & Nyangarika, 2025).

Table 7 Economic Feasibility Indicators of Onion Production under Irrigated Conditions

Indicator	**Unit**	**Value**
Gross Revenue	ETB ha^{-1}	1,120,000
Total Cost	ETB ha^{-1}	646,880
Net Return	ETB ha^{-1}	473,120
Return on Investment (ROI)	%	73.14
Profitability Index (PI)	Ratio	1.73
Input–Output Ratio (IOR)	Ratio	1.73
Net Return per Birr Invested	ETB ETB^{-1}	0.73
Break-Even Yield	t ha^{-1}	16.17
Break-Even Price	ETB kg^{-1}	23.1
Margin of Safety (Yield)	%	42.24

Margin of Safety (Price)	%	42.25
Payback Period	Seasons	1.37
Investment Attractiveness	Rating	High

CONCLUSIONS AND RECOMMENDATIONS

1.11 Conclusions

This study evaluated the economic performance and feasibility of onion production under irrigated conditions in the Gebiresu Zone of the Afar National Regional State, Ethiopia. The findings demonstrated that irrigated onion production is a profitable and economically viable enterprise. With an average yield of 28 t ha^{-1} and a farm-gate selling price of 40 ETB kg^{-1}, producers generated a gross revenue of 1,120,000 ETB ha^{-1} and a net return of 473,120 ETB ha^{-1}. The benefit-cost ratio (1.73), return on investment (73.14%), and break-even yield (16.17 t ha^{-1}) further confirmed the economic attractiveness and financial sustainability of onion production under the prevailing production conditions.

The cost structure analysis revealed that marketing costs constituted the largest share of total production and marketing expenses (38.64%), followed by chemical management (13.92%), labor (11.75%), and fertilizer costs (9.28%). Together, these four components accounted for more than 70% of total production costs, indicating that profitability is strongly influenced by market-related expenses and input management practices. The dominance of marketing costs suggests the existence of inefficiencies in market access, transportation, and transaction systems that reduce producers' profit margins.

Despite these constraints, the actual yield substantially exceeded the break-even yield, indicating a considerable margin of economic safety and low financial risk. The positive net returns and favorable economic indicators demonstrate that irrigated onion production has significant potential to enhance household income, generate rural employment, and contribute to agricultural commercialization in the study area. Therefore, improving market efficiency, input-use effectiveness, and production management practices would further strengthen the profitability and competitiveness of onion farming in the Gebiresu Zone.

1.12 Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance the profitability, competitiveness, and sustainability of irrigated onion production in the Gebiresu Zone of the Afar National Regional State.

i. Recommendations for Onion Producers

1. Producers should strengthen collective marketing through cooperatives and producer associations to reduce dependence on brokers and improve bargaining power. Since marketing

costs accounted for 38.64% of total production costs, collective marketing arrangements could substantially reduce transaction costs and increase producers' net returns.

2. Producers should adopt integrated pest management (IPM) and soil-test-based fertilizer application practices to improve input-use efficiency. Given that chemical management and fertilizer costs together represented 23.20% of total production costs, more efficient input utilization could significantly reduce production expenses without compromising productivity.
3. Producers should maintain proper farm records on input use, labor requirements, production costs, and revenues to support evidence-based farm management and marketing decisions.

ii. *Recommendations for Cooperatives and Producer Organizations*

1. Cooperatives should facilitate collective input procurement and bulk marketing to reduce production and transaction costs. Bulk purchasing of fertilizers, pesticides, and seed can lower input costs, while collective marketing can improve access to better market prices.
2. Producer organizations should establish market information platforms that provide timely information on prices, market demand, and buyer opportunities. Improved market information can reduce information asymmetry and strengthen farmers' negotiating capacity.

iii. Recommendations for Agricultural Extension Services

1. Extension services should intensify training on integrated nutrient management, integrated pest management, efficient irrigation practices, and post-harvest handling techniques to improve productivity and profitability.
2. Demonstration programs should promote labor-saving technologies and improved production practices. Since labor costs accounted for 11.75% of total production costs, increased adoption of appropriate mechanization could substantially improve labor productivity and reduce production expenses.

iv. Recommendations for Policymakers and Government Institutions

1. Priority should be given to investments in rural roads, market centers, storage facilities, and transportation infrastructure. Because marketing expenses represented the largest cost component (38.64%), improving market infrastructure could generate the greatest impact on farm profitability.
2. Government institutions should strengthen agricultural credit programs and improve access to affordable production inputs. Enhanced access to finance would enable producers to adopt improved technologies, purchase quality inputs, and expand production.
3. Investments in irrigation infrastructure and water management services should be expanded to ensure reliable water supply and sustain productivity under irrigated production systems.
4. Policymakers should strengthen agricultural market information systems and support value-chain development initiatives that improve market transparency and reduce transaction costs.

v. Recommendations for Development Partners and Research Institutions

1. Development partners should support value-chain interventions that improve market linkages, storage facilities, and post-harvest management systems to reduce losses and increase producers' market participation.
2. Research institutions should conduct further studies on cost-reduction technologies, improved onion production practices, and market-chain efficiency to identify innovations that enhance profitability and competitiveness.

Ethical Statement

This research was conducted in accordance with ethical standards applicable to socio-economic and agricultural field studies. Before data collection, informed consent was obtained from all participating producers and stakeholders. Participants were briefed on the objectives of the study, and their involvement was entirely voluntary. Data collected were kept confidential and used strictly for research purposes. No personal identifiers were disclosed, and findings are presented in an aggregated format to ensure anonymity. The study adhered to the research ethics guidelines of the Ethiopian Institute of Agricultural Research (EIAR), and no part of the study posed harm or risk to participants or the environment.

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Declaration of Conflict of Interests

The authors hereby declare that all authors of this manuscript have no conflicts of interest in this study.

Ethical Clearance

This research involves a survey-based study and does not include any experimental interventions, medical procedures, or activities that could cause physical, psychological, or social harm to participants. All participation was voluntary, and informed consent was obtained from respondents before data collection. No personal identifiers were recorded, and all information was kept strictly confidential. The study was conducted in accordance with ethical research guidelines and poses no risk to any individual or group.

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Authorship

The authorship of this research is as follows:

- ✓ **Yitages Kuma Beji:** Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing original draft, Writing, review & editing
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