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The Competitiveness of Tomato Value Chain, Kenya

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Abstract:
Tomato (Lycopersicon esculentum mill) is an important vegetable, ranked number three among the vegetables. The vegetable contributes about 31.8% to domestic horticulture and is ranked in the following order: Kales, Cabbages, Tomatoes, Cowpeas, Spider plants, Snow peas, Nightshade and Amaranth. Tomato fruits can be used as salads, cooked as vegetables, processed into tomato paste (puree), tomato sauce, ketchup, juice and sun-dried tomato. This study only analysed tomato fruits and did not study the products of tomato fruits. Tomato production is grown in most of the agro-ecological zones in the country. There is a high demand for tomato consumption in the country because every household uses tomato and the performance of tomato production could depend on the production system in place. There are two production systems, the open field and the protected environment system (greenhouse technology or screen house technology) and the two production systems have different performance potential. The greenhouse technology is only 10% adoption rate and the open field technology is 90% adoption rate. The greenhouse technology supposedly produces more up to tenfold compared to open field technology. The open field technology and the greenhouse technology use the determinate and indeterminate tomato varieties, respectively. This study, therefore, purposed to determine the profitability level of the two tomato production systems in Kenya. The study used documents from Horticulture Development Authority, Kenya Agriculture Livestock Research Organization, Amiran Kenya Limited and Ministry of Agriculture, Livestock and Fisheries. Partial budgeting analysis and Breakeven analysis were used to determine profitability. The net return obtained for using equivalent greenhouse technology over the open field technology in one acre of land was Ksh 1,328,320 in one production season. The average net return was Ksh 127,478 per greenhouse technology in one production season. There was also an average net return of Ksh 127.5 per plant. The Breakeven analysis in greenhouse technology was 335,010.137 kgs of Tomatoes in one production season. The Breakeven analysis in greenhouse technology per one greenhouse was 32,150.685kgs of tomatoes. Therefore, only 1.6 production seasons are required to breakeven. Thus, it can be concluded from the study that it is economically worthwhile to use greenhouse technology in tomato production in Kenya.

Keywords: *Tomato, Open field technology, Greenhouse technology, Partial budgeting analysis and Breakeven analysis*

1. Introduction

The Agriculture sector is the mainstay of the economy in Kenya, contributing 30% of the GDP and 80% of the employment. According to the Kenya Economic Survey 2014, the leading agriculture subsectors in order of importance were Dairy, Tea and Horticulture. Horticulture contributes about 33% of the Agricultural GDP and 1.45% of the National GDP and is a fast-growing sub-sector with small-scale farmers (below 10 acres) contributing about 50-60% of the total production. About 95% of horticultural production goes to the domestic market and 5% to the export market. Horticulture industry is the second foreign exchange earner for the country (after tourism), generating approximately KES 90 billion in 2015.

Horticulture is a fast-growing subsector and is a source of income, food security and foreign exchange to the economy. Horticulture is made of Vegetables (44.6%), Flowers (20.3%), Fruits (29.6%), nuts, medicinal and aromatic plants (MAPs) (5.8%) (HCDA, 2014). The domestic value of horticulture production in 2014 amounted to Ksh 196 billion and the cultivated area was 605,057 Ha and the total production was 7.9 million metric tonnes. The Horticulture export volume was 220,248,000 Kg and the export value was KES 84,084,000,000. Vegetables contributed 36% to the domestic value of horticulture, the area cultivated was 326,837 Ha and the amount produced was 4.1 million metric tonnes. The leading vegetables in order of importance were; Irish potatoes, tomatoes and cabbages.

Tomato (Lycopersicon esculentum Mill) originated in South America in Peru and Mexico (Zhang et al., 2021). The world's tomato production is estimated at 186,821 million tonnes, with a cultivated area of about 5,051,983 hectares. China is the leading tomato producer with over 16 million tonnes of annual production (much of it consumed domestically, they export only 0.6%), followed by the USA (over 5.2 million tonnes) and India (over 4.1 million tonnes). Egypt is the fifth in the world but first in Africa and Kenya could be the 14th with 590,000 tonnes in 2010 and the first in East and Central

Africa. The biggest exporter of fresh tomatoes is Mexico, with over 1.1 million tonnes, followed by the Netherlands (over 0.97 million tonnes) and Spain (over 0.82 million tonnes). The biggest importer of fresh tomatoes is Mexico, with over 420,000 tonnes, followed by China (over 390,000 tonnes) and Turkey (over 125,000 tonnes). Kenya produced 590,000 tonnes for sale, and approximately 60-70% reached the market for selling both fresh and processed tomatoes. Kenya exported in the region 3,380 metric tonnes of processed tomato products between 2006 and 2010, worth 209.7 million ($2.9 million), with the destination being Tanzania, Sudan and Uganda.

Tomato production in Kenya is barely sufficient to satisfy local domestic market demands, especially for processing or export. There are many processing companies like Premier food industry, Trufoods, Lyons, Nestle, Vega company, and Demonte, making products such as tomato sauce, tomato juice, chilli sauce, chilli cubes and others. The Kenyan government has been striving to achieve national household and individual food and nutrition security to address inaccessibility to food which is closely linked to poverty which stands at 46% nationally. The initiative to attain food and nutrition security is anchored in the Kenya climate smart Agriculture strategy (2017-2026) that envisions a climate resilient and low carbon growth sustainable agriculture that contributes to the national development goals in line with Kenya's vision 2030. 90% of the world tomato production is in the open field and only 10% of tomato production is under greenhouse technology, whose adoption is still low despite the high benefits accrued to it. The selection of tomato varieties for production is essential because there are varieties for fresh produce and processing. The tomato varieties for fresh produce are also known as determinate varieties and tomato varieties for processing are known as indeterminate varieties. Determinate varieties are short and bushy tomato varieties that produce stems that end with flower clusters. They ripen early, are easier to harvest, have more concentrated fruit maturity, and are appropriate for open-field technology. The indeterminate tomato varieties produce new leaves and flowers continuously and hence grow very tall > 2 metres. They must be staked and continuously pruned. The indeterminate tomato varieties are mostly used in greenhouse technology and they are also good for processing, while the determinate tomato varieties are appropriate for open-field technology. One acre of land is capable of holding 11,200 open-field tomato plants and assuming that each plant produces 3 kilograms of tomato fruits, you should harvest about 30 tonnes per acre for open-pollinated varieties like Rio Grande. Other hybrid tomato varieties are capable of giving up to 40-50 tonnes per acre. The top tomato varieties suitable for open-field technology are indicated in table 1.

Rambo F1	Star 9065
Oxly	Kilele F1
Rio Grande	Galilea F1 improved
Tylka F1	Shanty F1
	Roma
	Cal-J
	Kentom F1
	Kubwa F1
	Randah F1

Table 1: Tomato Varieties for Open Field Technology
Source: HCD (2015)

One greenhouse tomato plant has the potential to give up to 15 kilograms at first harvest and up to 60 kilograms by the time it has completed its full cycle, which is 1 year (Makunike, 2007). The yield of tomatoes in greenhouse technology is said to be at least 10 times more than the yield in open-field production (Seminis-Kenya, 2007). The top tomato varieties for greenhouse technology are shown in table 2.

EVA F1	Anna F1
Steve F1	Corazon F1
Tylka F1	Bravo F1
	Chonto F1
	Prostar F1

Table 2: Tomato Varieties for Greenhouse Technology
Source. HCD (2015)

Tomato production in Kenya, with Kajiado, Bungoma and Kirinyaga as leading counties in the order of importance, is shown in table 3.

Counties	Areas (Ha)	Quantity (Tonnes)	Value (Kshs) Millions	Share by Value
Kajiado	1680	47368	1624	13.7%
Bungoma	1700	50399	1611	13.6%
Kirinyaga	1648	48560	1156	9.7%
Makueni	558	21096	857	7.2%
Kiambu	964	18029	812	6.8%
Trans Nzoia	628	14848	416	3.5%
Machakos	447	6189	356	3.0%
Kisii	937	16664	351	2.9%
Nakuru	633	17511	347	2.9%
Kisumu	1477	16720	328	2.7%
All counties total	24074	400,204	11,803	100%

Table 3: Production of Tomato in Leading Counties in Kenya
Source: HCDA (2015)

Open-field tomato production, which is 90% practiced worldwide, is hampered by high temperatures, drought and high incidences of pests and disease, leading to low yields and farm incomes. The Alternative, which is greenhouse technology, is only 10% practiced in the whole world (Seminis-Kenya,2007) and protects crops against high solar radiation and heavy rainfall, leading to better yields and farm incomes. There are several types of greenhouse technology with estimated selling prices and also with several other attributes, as shown in table 4.

Greenhouse Structure				Aluminum Tunnel	
8x30m	240m²	1000	15-20(20-43)	15-20(20-40)	190,000
			Wooden Greenhouse		
6x10m	60m²	300	15-20(20-40)	4.5-6(6-12)	60,000
6x15m	90m²	500	15-20(20-40)	7.5-10(10-20)	70,000
6x20m	120m²	700	15-20(20-40)	10-14(14-28)	130,000
6x25m	150m²	800	15-20(20-40)	15-20(16-32)	140,000
6x30m	180m²	1000	15-20(20-40)	7.5-10(20-40)	165,000

Table 4: Projection of Greenhouse Technology Measurement Size No. of Plants
Yields per Plant per Total Yields per Unit Estimated Cost of Season (Kg) Season (Tonnes)
Note: Values in the Parentheses Indicate Achievable Yields with Better Management Practices
Source: Odame (2009)

The literature from the empirical studies shows that farmers can get 10 times the yield with a greenhouse production system than with the open field system of production (Seminis-Kenya, 2007). Wachira, J. M. et al. (2014) found out that the mean gross margins were KES 14.92/m² and KES 288.34/m² for the open field and greenhouse tomato production systems and this was statistically significant at 5%. The mean net profit was KES 12.99/m² and KES 169.11/m² for open field and greenhouse tomato production systems, respectively and statistically significant at 10%. These results reveal that the net profit for greenhouse tomato growers was thirteen times higher than that for the open-field production system. This study, therefore, assesses the profitability of the greenhouse tomato production system over the open field tomato production system in Kenya using partial budget analysis and breakeven point analysis.

2. Materials and Methods

2.1. Study Design

The study checked on documents from the industrial player, Amiran Ltd and Ministry of Agriculture, Livestock and Fisheries Development (MOA, L &F DVPT) and various authors on data in greenhouse production, open field production and projections in greenhouse production.

2.2. Partial Budget Analysis

A partial farm budget analysis was used to estimate the profitability level of the Tomato value chain. Partial budgeting provides a simple economic description and comparison of different production systems in Tomato production (Dijkhuizen et al., 1995; Tenesi et al., 2023). The partial budget framework and the components and parameters used are shown in tables 3 and 4, respectively.

1. Additional returns
2. Costs no longer incurred
3. Subtotal: 1 + 2
4. Foregone returns 5. Additional costs 6. Subtotal: 4+5
7. Difference: 3 – 6: Derived net return. If the net return is negative, then the procedure is not recommended and vice versa.

Table 5: Partial Farm Budget Framework

Parameters	Components Considered
Additional returns	1. Tomato revenue
Additional costs incurred	1. Greenhouse 30m *8m wooden 2. Irrigation system 3. Seedlings 4. Manure 5. Chemicals
Costs No longer incurred	1. Nursery management 2. Land preparation, planting and fertilizer application 3. Weeding and topdressing 4. Spraying 5. Watering 6. Harvesting and grading 7. Market preparation 8. Interest in working capital
Foregone returns	-

Table 6: Parameters and Components of Partial Budget Analysis in Tomato Value Chain, Kenya

2.3. Breakeven Analysis

To conduct a breakeven analysis, the following components are required, as shown in table 7.

Parameters	Components Considered
Fixed costs	1. Cost of greenhouse 30m *8m wooden *10.42 2. Irrigation system *10.42 3. Total fixed costs (1 + 2)
Variable costs	1.Seedlings =KES 2. Pesticides =KES 3. Growth hormone =KES 4.Fertilize = KES 5. Manure = KES 6. Total variable cost per kg (1+2+3+4+5) = KES
Sales price	1. 1000 tomato plants @20kgs = 20,000 kg 2. Unit cost per kg = KES 3. Sales price per kg = KES
Unit contribution margin	Sales price – Variable cost = KES
Breakeven point (in units)	1. Fixed costs/unit contribution margin 2.
Breakeven point (in revenue)	1. Fixed costs / (unit selling price – unit variable price) * selling price 2.

Table 7: Parameters and Components of Breakeven Analysis of Tomato Value Chain in Kenya (Greenhouse 1 Acre)

3. Data Management and Analysis

The partial budget analysis was computed based on the partial budget framework (Table 5) and parameters and components of partial budget analysis in the Tomato value chain (Table 6). The Breakeven analysis was computed based on table 7.

4. Results

4.1. Partial Budget Analysis of Tomato Value Chain

A partial farm budget analysis was used to estimate the profitability level of the Tomato value chain.

4.2. Tomato Value Chain

Tomato production in Kenya and worldwide is cultivated in two production systems: The open field production system and the protected production system (greenhouse and/or screen house). 90% of the production systems is the open field and the remaining 10% is the protected production system.

The Gross margin for tomato production under greenhouse technology in Kenya is shown in table 8. They were collected from Amiran-Kenya website.

The Gross margin for Tomato production under open-field technology in Kenya is shown in table 9. They were collected from Ministry of Agriculture, Nakuru County, Kenya.

The net return of greenhouse tomato production over the open-field tomato production system is shown in table 10. This is the table that produces the four components of partial budgeting analysis. (Additional returns + Costs no longer incurred) – (Additional costs incurred + Foregone returns) = Net return.

Item	Unit	Kshs	Kshs
			Unit Cost
A Construction cost			
Greenhouse 30m x8m wooden	1	208,700	208,700
Irrigation system	1	26,000	26,000
Total fixed cost			234,000
B Establishment cost			
Seedling	1000	2.0	2,000
Pesticides (insecticides, fungicides)		7,000	7,000
Growth hormone (flowering)		2,000	2,000
Fertilizer DAP, CAN, Foliar feed	25kg	200	5,000
Manure	3 tonnes	1,500	4,500
Total variable cost			20,500
C Expected Revenue			
1000 Tomato plants @20kgs	20,000kg	20	400,000
Total cost			255,000
Gross margin (240m2)			144,000
Gross margin (one acre)			1,508,333
NB: Labour costs for management not included			

Table 8: Gross Margin for Tomato Production under Greenhouse Technology (One Acre)
Source: Amiran Website

Item	Unit	Quantity	Unit Cost	Total cost
Land preparation	One acre	1	2,500	2,500
Seeds	100gram	2	400	800
Chemicals			13,500	
Nursery management	Labour (MD)	4	250	1,000
Land preparation, planting	Labour (MD)	26	250	6,500
and fertilizer application				
Weeding (1, 2, 3) and top	Labour (MD)	36	250	9,000
dressing				
Spraying	Labour (MD)	6	250	1,500
Watering (irrigation)	Labour (MD)	10	250	2,500
Harvesting and grading	Labour (MD)	70	250	17,500
Market Preparation	Labour (MD)	18	250	4,500
Total variables			46,000	
Interest in working capital	Kshs	0.12	46,700	5,604
Total gross output	Crate	400	700	280,000
Gross margin			227,000	

Table 9: Gross Margin for Tomato (Cal J) under Open Field Production
Source: Ministry of Agriculture, Nakuru County (2014)

Parameter
*Additional returns Tomato revenue Kshs (4168000-280,000) = Kshs 3,888,000
Additional costs incurred Cost of Greenhouse Kshs 2,174,654 Cost of irrigation system Kshs (270,920 -2500) = Kshs 268,420 Cost of seedlings Kshs (20,840-800) = Kshs 20,040 Cost of manure Kshs 46,890 Costs of growth hormone Kshs 20,840 Costs of Chemicals Kshs (72,940 – 13,500) = Kshs 59,440
Foregone returns
Costs no longer incurred Costs of nursery management Kshs 1000 Costs of land preparation, planting and fertilizer application Kshs 6500 Costs of weeding and topdressing Kshs 9000 Cost of spraying Kshs 1500 Cost of watering (irrigation) Kshs 2500 Costs of market preparation Kshs 4500 Costs of interest on working capital Kshs 5604 Net return =Kshs (3,888,000+1000+6500+9000+1500+2500+4500+5604) – (2,174,654+268,420+20,040+46,890+20840+59.440) = Kshs 1,328,320 Average net return per plant = Kshs 127.5 Average net return per greenhouse = Kshs 127,478

Table 10: Net Return of Tomato Value Chain in a Protected Environment in Kenya
** Average Exchange Rate to US Dollars Was Kshs. 87.8*

The Tomato value chain with greenhouse technology realized a net return of Kshs. 127,478 per greenhouse technology. The total net return was Kshs. 1,328,320 for about 10 greenhouses technology of size 8M *30M in Kenya.

Parameters	Components Considered
Fixed costs	1. Cost of greenhouse 30m *8m wooden *10.42 =KES 2,174,654 2. Irrigation system *10.42 = KES 270,920 3. Total fixed costs (2,174,654 + 270,920) = KES 2,445,574
Variable costs	1.Seedlings =KES 2.00 2. Pesticides =KES 7.00 3. Growth hormone =KES 2.00 4.Fertilize = KES 0.20 5. Manure = KES 1.50 6. Total variable cost per kg = KES 12.7
Sales price	1. 1000 tomato plants @20kgs = 20,000 kg 2. Unit cost per kg = KES 20.00 3. Sales price per kg = KES 20.00
Unit contribution margin	Sales price – Variable cost = KES 20 – KES 12.7 = KES 7.3
Breakeven point (in units) in one production season in one acre with greenhouse technology	1. Fixed costs/unit contribution margin 2. 2,445,574/7.3 = 335,010.137 kgs
Breakeven point (in revenue) in one production season in one acre with greenhouse technology	1. Fixed costs/(unit selling price – unit variable price) * selling price 2. 2,445,574/7.3 * 20 = KES 6,700,202.74
Actual production in one production season in one acre with greenhouse technology	20,000 *10.42 = 208,400 kgs
Number of production systems required to breakeven	335,010.137/208,400 = 1.6 production seasons
Breakeven units in one production system per greenhouse (30m *8m wooden)	335,010.137/10.42 = 32,150.685 kgs

Table 11: Parameters and Components of Breakeven Analysis of Tomato Value Chain in Kenya (Greenhouse 1 Acre)

5. Discussion

Partial budgeting analysis and Breakeven analysis results of the study showed that the Tomato value chain with greenhouse technology was financially profitable. The Tomato value chain with greenhouse technology realized a net return of Ksh. 127,478 per greenhouse technology as per partial budgeting analysis. The breakeven analysis per a greenhouse technology was 32,021.8kgs compared to the actual production of 20,000kgs; hence 1.6 production seasons are required to breakeven. This study is in agreement with the previous studies of Seminis-Kenya,2007, Wachira, J.M,2014 and Makunike 2007. This was a significant generalization to the whole Country, Kenya, because it shows a positive net return in greenhouse technology. High net returns are indicators of the high profitability of greenhouse technology. Therefore, this can be concluded from the study that it was still economically worthwhile to use greenhouse technology in Tomato production.

6. Conclusion and Recommendations

The partial costs and partial benefits showed partial net benefits when the greenhouse technology was applied. Comprehensive financial and economic analysis needs to be taken for the financial viability assessment of the greenhouse technology. Also, the Tomato value products need comprehensive assessment of their profitability.

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