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Research Article

Influence of Agricultural Input Subsidy on Potato Profitability Among Smallholder Farmers in Marakwet West Sub-County, Elgeyo Marakwet County (Kenya)

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Abstract

This study examined the influence of agricultural input subsidies on the profitability of Irish potato production among smallholder farmers in Marakwet West Sub-county, Elgeyo Marakwet County, Kenya. Agricultural input subsidies, particularly for fertilizers and certified seeds, are widely recognized as policy tools for enhancing smallholder productivity and household incomes, yet their profitability outcomes remain underexplored in highland potato-growing areas of Kenya. The study adopted a descriptive survey design and targeted 5,499 smallholder potato farmers, from which 326 respondents were selected using stratified random sampling. Primary data were collected through structured questionnaires and supplemented with field observations and secondary records from the Department of Agriculture. Data analysis involved descriptive statistics, enterprise budgeting, and multiple linear regression to determine the effect of subsidies on profitability. Results revealed that 58% of farmers accessed fertilizer subsidies and 83% accessed seed subsidies, with average coverage meeting 91% and 72% of total input needs, respectively. Profitability analysis showed that farmers receiving both fertilizer and seed subsidies achieved the highest net returns above total variable costs (Ksh 718,564) and profit margins (69%), compared to only 31% for farmers without subsidies. Regression results confirmed that the quantity of subsidized fertilizers received, access to certified seed subsidies, and combined input support were significant positive predictors of profitability ($p < 0.05$). Conversely, higher subsidized seed prices were negatively associated with net returns, highlighting the importance of affordable input delivery. The study concludes that integrated fertilizer and seed subsidies substantially enhance smallholder potato profitability and recommends timely, multi-seasonal distribution of adequate input packages alongside improved market access and post-harvest management to sustain economic gains. Implementing these measures would strengthen household incomes, promote market-oriented production, and support Kenya's broader agricultural transformation agenda.

Keywords

Agricultural Subsidy, Irish Potato Yields, Smallholder Farmers, Elgeyo Marakwet, Kenya, Profitability

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1. Introduction

Agricultural input subsidies are widely recognized as a policy tool for enhancing smallholder productivity and improving farm profitability, particularly in developing economies where resource constraints hinder optimal agricultural production. By reducing the cost of essential inputs such as fertilizers and certified seeds, subsidies aim to stimulate adoption of yield-enhancing technologies, lower production costs, and ultimately increase farm incomes [1, 2]. Global evidence from Asia, Latin America, and Sub-Saharan Africa shows that input subsidies, when well-designed and targeted, can contribute to farm profitability, rural livelihood diversification, and improved food security [3, 4]. However, the impact on profitability is not automatic; it depends on factors such as subsidy coverage, timeliness of delivery, access to complementary services, and prevailing market conditions.

In Sub-Saharan Africa (SSA), input subsidies are widely used as a strategy to reduce structural barriers that hinder farmers from accessing critical inputs, with the aim of enhancing both yield and economic returns [2, 4]. However, global experiences have shown that the profitability impact of subsidies is context-specific, depending on input cost reductions, timely delivery, market linkages, and environmental suitability. Poorly designed subsidies can sometimes distort markets, create dependency, or fail to translate yield gains into sustainable profits [5].

In Kenya, smallholder farming dominates the agricultural landscape, contributing approximately 75% of the country's total agricultural output and 80% of employment in rural areas [6]. Input subsidy programs, primarily for fertilizers and certified seeds, have been implemented to enhance both productivity and profitability of key crops such as maize, wheat, and Irish potatoes. While these programs reduce input costs, evidence on their profitability impact remains mixed, as smallholder farmers often face challenges related to fluctuating market prices, high post-harvest losses, and input distribution inefficiencies [7, 8]. Profitability, therefore, is influenced not only by the volume of output produced but also by the balance between production costs and market returns, highlighting the need for integrated evaluations beyond yield measurements.

Irish potato (*Solanum tuberosum* L.) is the second most important food crop in Kenya after maize, playing a critical role in household incomes and national food security. The crop is widely cultivated in the highland counties including Elgeyo Marakwet, Nakuru, Meru, Nyandarua, and Bomet, where the cool climate and fertile soils support intensive production [9]. Despite its potential, smallholder potato farming often suffers from low profitability due to limited access to affordable certified seed, suboptimal fertilizer use, high input prices, and market volatility. Studies have shown that subsidies can enhance profitability by lowering input costs and increasing marketable yields; however, the net benefit depends on whether increased yields translate into favorable revenue after accounting for labor, transport, and other production costs [10, 11].

Marakwet West Sub-County in Elgeyo Marakwet County is an emerging potato production hub characterized by bimodal rainfall, mid- and high-altitude zones, and strong smallholder participation. The county government, in collaboration with national programs, has implemented input subsidy schemes targeting fertilizers and certified potato seeds to enhance both productivity and profitability among smallholder farmers [12]. However, profitability outcomes remain uncertain due to heterogeneity in subsidy access, market price fluctuations, and differences in household resource endowment. Assessing the influence of input subsidies on potato profitability in this context is critical for understanding whether subsidies deliver meaningful economic returns for smallholder farmers, and how such programs can be optimized for sustainable rural development.

This study, therefore, seeks to evaluate the influence of agricultural input subsidies on the profitability of smallholder potato farming in Marakwet West Sub-County. By examining fertilizer and seed subsidy access, frequency, quantity, and associated cost-benefit outcomes, the research provides evidence to guide policy makers and implementers in enhancing the economic viability of input support programs. The findings will contribute to designing subsidy programs that not only raise yields but also improve net farm returns, supporting both household welfare and county-level agricultural transformation.

2. Methodology

2.1. Study Area

This study was undertaken in Marakwet West Sub-County, one of the sub-counties in Elgeyo Marakwet County in the Rift Valley. The county has a population of 454,480 [13] and three agro-ecological zones: the valley, mid-highland, and highland. Marakwet West has a total population of 137,513 within 29,523 households [13]. The sub-county consists of six wards: Kapsowar, Lelan, Sengwer, Cherang'any/Chebororwa, Moiben/Kuserwo, and Arror. Irish potato is grown in all wards except Arror, located in the Kerio Valley basin. Temperatures range from 14 ℃ to 24 ℃, and rainfall ranges from 400 mm to 1400 mm annually [14].

2.2. Research Design

The study adopted an explanatory research design because it establishes cause-and-effect relationships between study variables. The cause was agricultural input subsidies, while the effects were threefold: potato production, income, and adoption of agricultural technologies. Correlation analysis, a key method in explanatory design, was used to evaluate the cause-effect relationship between two or more quantitative variables [15].

2.3. Target Population

The target population comprised smallholder Irish potato farmers in Marakwet West Sub-County who benefited from the government's fertilizer and seed subsidy programme. According to the Elgeyo Marakwet Agriculture Annual Report [14], the total number of smallholder potato farmers was 5,499 across five potato-producing wards (Table 1). Arror Ward was excluded as no potato production was reported there.

Among the wards, Lelan had the highest concentration of potato farmers (1,545; 28.1%), reflecting its favorable highland conditions for potato production. Moiben/Kuserwo followed with 1,400 farmers (25.5%), Cherang'any/Chebororwa with 850 (15.5%), Sengwer with 944 (17.2%), and Kapsowar with 760 (13.8%). This distribution shows spatial variation in potato farming intensity influenced by elevation, rainfall, and land availability, which guided proportional sampling during the survey [16].

2.4. Sample Size

The sample size of the study was calculated by using the Slovins formula [17] with a 95% confidence level as:

$$n = \frac{N}{1+Ne^2} = \frac{5499}{1+5499*0.05^2} = 372.87 \approx 372$$

Where: n = Sample size required

N = Number of people in the population

e = Allowable error (5%) 0.05 for population 1,000 to 10,000

Therefore, the sample size for this study was 372 potato farmers.

2.5. Sampling Procedure

A proportional stratified random sampling technique was applied, with the five potato-producing wards serving as strata [18]. Farmer lists from ward agricultural offices were used to determine proportional representation from each stratum, after which simple random sampling was applied to select 372 respondents. This ensured a representative sample reflecting spatial diversity in potato production.

Table 1. Population, proportion, and sample size of smallholder potato farmers per ward in Marakwet West Sub-County (2023).

Ward	Population	Proportion	Sample size
Cherang'any/Chebororwa	850	15.5	58
Moiben/Kuserwo	1400	25.5	95
Kapsowar	760	13.8	51
Lelan	1545	28.1	105
Sengwer	944	17.2	64
Total	5,499	100.0	372

Source: Author's tabulation (2023)

2.6. Data and Research Instruments

Primary data was collected from 372 farmers through structured questionnaires, interviews with extension officers, and an observation checklist [15].

Questionnaire: Captured data on subsidy inputs, production, profitability, and technology adoption. Interview guide: Used to obtain expert insights from key stakeholders on subsidy logistics. Observation checklist: Documented field conditions of potato production.

2.6.1. Validity and Reliability of Instruments

Content validity was ensured through expert review by county agricultural officers [19]. Suggestions were integrated into the final tools. Criterion validity was supported by aligning instruments with standard agricultural monitoring frameworks.

Reliability was tested through a pilot study with 10% (37) of the sample in Kapchemutwa Ward, Keiyo North Sub-County. Cronbach's Alpha ≥0.70 indicated acceptable internal consistency [20].

2.6.2. Pre-testing of Research Instruments

The research instruments were pre-tested among 10% (37) of the sample in Kapchemutwa Ward, Keiyo North Sub-County, which was not included in the final survey. The pretest was conducted to assess the clarity, relevance, and consistency of the questionnaire items. Feedback from the pre-test was used to refine question wording, improve sequencing, and eliminate ambiguities before the main data collection exercise.

2.7. Data Collection Procedures

A research permit was obtained from National Commission for Science and Technology (NACOSTI), and authorization from the County Government was secured before data collection. Surveys and interviews were conducted from March to June 2024.

2.8. Data Analysis and Presentation

Filled questionnaires were screened; coded and entered in IBM Statistical Packages for Social Sciences (SPSS) version 26.0. The collected data was analyzed using appropriate statistical methods to address the research objectives. The analysis involved both descriptive and inferential statistics. Descriptive statistics was used to summarize the characteristics of the variables. Frequency distributions (%) were used for categorical variables. To evaluate the influence of agricultural input subsidies on Irish potato profitability among smallholder farmers, a multiple linear regression model was estimated. Profitability was measured as net returns above total variable costs (KSh per production season). The regression model was specified as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 \ldots + \varepsilon_i$$

Where

Y = Profitability of Irish potato farming (net returns above total variable costs, KSh per season)

X_1 = Receipt of fertilizer subsidy (dummy variable: 1 = yes, 0 = no)

X_2 = Price of subsidized fertilizer (KSh per 50-kg bag)

X_3 = Type of subsidized fertilizer (categorical variable: NPK, Urea, or both)

X_4 = Quantity of subsidized fertilizer received (kilograms per season)

X_5 = Receipt of seed subsidy (dummy variable: 1 = yes, 0 = no)

X_6 = Price of subsidized seed (KSh per kilogram)

X_7 = Type of subsidized seed (categorical variable: certified, local, or apical)

X_8 = Quantity of subsidized seed received (kilograms per season)

X_9 = Receipt of both fertilizer and seed subsidies (dummy variable: 1 = yes, 0 = no)

β_0 = Intercept term

β_1–β_9 = Regression coefficients

ε = Error term

Diagnostic tests was conducted on the regression results obtained from the analytical approach, specifically the SPSS output. These tests aim to assess the assumptions underlying the chosen analytical model, which in this study is multiple linear regression using ordinary least squares. Multicollinearity, which refers to the correlation between independent variables, was assessed using the Variance Inflation Factor (VIF) in SPSS [21]. The VIF measures the extent to which the variance of an estimated regression coefficient is inflated due to multicollinearity. A VIF of 1 indicates no correlation, while values between 1 and 5 suggest moderate correlation that does not require corrective measures. VIFs greater than 5 indicate severe multicollinearity, which can lead to unreliable coefficient estimates and questionable p-values (add citation).

2.9. Ethical Considerations

The study adhered to research ethics, including confidentiality, voluntary participation, and informed consent [22]. Personal identifiers were excluded to protect respondent privacy. Research integrity was maintained by avoiding bias and respecting intellectual property.

3. Results

3.1. Questionnaire Response Rate and Reliability

A total of 372 of questionnaires were distributed to the smallholder potato farmers, out of which 326 were returned and used in the current analysis. This resulted in a response rate of 87.6%. This response rate was considered good, since an overall response rate of 60-100% adequately validates such studies in the past (add citation)

The overall reliability of the questionnaire during this study was 0.87. A reliability value above 0.6 is adequate to accept the research instrument's internal consistency. Therefore the high reliability value above 0.6 showed that the questionnaires were good for analysis.

3.2. Socio-economic Status of Smallholder Potato Farmers

This section provides the results of the socio-economic profiles of the smallholder Potato farmers including age, household size, gender, level of education, and occupation. A summary statistics showing the mean age and household size is shown in Table 2.

Table 2. Socio-demographic characteristics of the small-holder potato farmers.

	Mean	Std. Dev.	Min.	Max.
Age	36.5	10.3	21	63
Household size	4.76	1.87	1	9
Land size (Acres)	3.24	1.13	0.2	7.8

Source: Author's computation Survey Data (2024)

The results indicate that the mean age of smallholder potato farmers in Marakwet West Sub-county was 36.5 ±10.3 years, suggesting that most farmers were middle-aged and within the economically active population. The average household size was 4.76 ± 1.87 members, which is consistent with the national rural household. The average land size ranged from 0.2 to 7.8 acres with an average of 3.25 acres.

Results of the gender, level of education and main economic activities in the household of the smallholder Potato farmers in Marakwet West Sub-county is shown in Table 3. The population was dominated by male genders, with primary level of education with dominance of crop farming.

Table 3. Gender, level of education and position in the household of the small-holder Potato farmers in Marakwet West Sub-county.

Attribute	Frequency	%
Gender		
Male	208	63.8
Female	118	36.2
Total	326	100
Level of education		
Primary	144	44.2
Secondary	120	36.8
Tertiary	54	16.6
University	8	2.5
Total	326	100
Main economic activities		
Crop farming	240	73.6
Keeping cattle	262	80.4
Trading activities	134	41.1
Formal employment	88	27
Total	724/326*	-

*Number is over 326 due to overlapping activities
Source: Author's computation Survey Data (2024)

3.3. Attributes of Fertilizer and Seeds Subsidies

Table 4 summarizes key attributes of government fertilizer and seed subsidies reported by smallholder Irish potato farmers between 2020 and 2022. Fertilizer subsidy attributes include frequency of access, quantities used and received, average prices, and fertilizer types. Seed subsidy attributes include access frequency, quantities used and received, average prices, and seed types/varieties. All prices have been converted to USD (1 USD ≈ Ksh 145)

Table 4. Consolidated Attributes of Fertilizer and Seed Subsidies among Smallholder Farmers in Marakwet West Sub-County, Kenya.

Attribute	Value
Fertilizer subsidy	
Farmers receiving subsidy (%)	58% received, 42% did not
Frequency of receiving fertilizer (None/Once/Twice)	None: 42.0%, Once: 48.8%, Twice: 9.2%
Avg. fertilizer used (kg/year ±SD)	584.8 ±204.5 kg
Avg. fertilizer received (kg/year ±SD)	537.4 ±138.5 kg
Avg. price of subsidized fertilizer (USD ±SD)	31.14 ±1.10
Avg. market price of fertilizer (USD ±SD)	48.24 ±1.77
Type of fertilizer received (NPK/Urea/Both)	NPK 94.2%, Urea 1.6%, Both 4.2%
Seed subsidy	
Farmers receiving subsidy (%)	83.1% received, 16.9% did not

Attribute	Value
Fertilizer subsidy	
Frequency of receiving seed (None/Once/Twice)	None: 16.9%, Once: 62.6%, Twice: 20.6%
Avg. seed used (kg/year ± SD)	2,553.1 ± 261.9 kg
Avg. seed received (kg/year ± SD)	1,600 ± 106.5 kg
Avg. price of subsidized seed (USD ± SD)	23.80 ± 2.93
Avg. market price of seed (USD ± SD)	34.63 ± 1.70
Type of seed received (Certified/Local/Apical)	Certified 77%, Local 12.6%, Apical 10.4%
Potato variety planted (Shangi/Tigoni/Alka)	Shangi 89.6%, Tigoni 5.2%, Alka 5.2%

3.4. Profitability of Potato Production

Enterprise budget analysis showed that revenue from potato farming was lowest among farmers who did not access any subsidy, earning an average of Kshs 473,600 annually (Table 5). Farmers who received fertilizer subsidies earned Kshs 820,800, while those who accessed seed subsidies earned Kshs 619,200. The highest revenue, Kshs 1,046,400, was realized by those who accessed both fertilizer and seed subsidies (Table 5). In terms of net returns above total variable costs (TVC), farmers without subsidies earned Kshs 145,764, while those with fertilizer and seed subsidies alone earned Kshs 458,439 and Kshs 291,364, respectively. The highest net return above TVC was Kshs 718,564 for those who accessed both subsidy types. Correspondingly, profit margins were 31% without subsidy, 56% with fertilizer subsidies, 47% with seed subsidies, and 69% with combined subsidies.

3.5. Regression Analysis on the Influence of Subsidies on Profitability

3.5.1. Multicollinearity Test Results

Multicollinearity diagnostic was conducted to assess the suitability of predictor variables used in the regression models evaluating the influence of agricultural subsidies on Irish potato production, profitability, and adoption of agricultural technologies (Table 6). Tolerance values and Variance Inflation Factors (VIF) were computed for each predictor. According to established thresholds (VIF < 5 and tolerance > 0.25), all predictors in the three models were within acceptable limits, indicating an absence of multicollinearity issues.

Table 5. *Enterprise budgeting of Irish potato production without subsidies, with seed or fertilizer subsidies, and with combined seed and fertilizer subsidies (2020–2023).*

Revenue from potato sales	Without subsidies	Fertilizer subsidy	Seed subsidies	Fertilizer and seed subsidies
Revenue from potato farming				
Average units of potato harvested (t/ha.)	9.8	17.1	12.9	22
Number of planting seasons	2	2	2	2
Unit cost of potato	24	24	24	24
Total revenue	473,600	820,800	619,200	1,046,400
Variable costs				
Cost of potato seeds	157976	17550	157976	157976
Cost of fertilizers	74177	77567	74177	74177
Cost of farm labour	35500	37767	35500	35500
Cost of herbicides	38000	43500	38000	38000

Revenue from potato sales	Without subsidies	Fertilizer subsidy	Seed subsidies	Fertilizer and seed subsidies
Revenue from potato farming				
Cost of land cultivation	7233	7667	7233	7233
Weeding costs	10283	20967	10283	10283
Harvesting costs	4667	6000	4667	4667
Total variable cost (TVC)	327,836	362,361	327,836	327,836
Fixed costs				
Land rates	10000	10000	10000	10000
Amortization	2400	2400	2400	2400
Interest on fixed cost	13,392	13,392	13,392	13,392
Total fixed cost	*25,792*	*25,792*	*25,792*	*25,792*
Total cost (TC)	353,628	388,153	353,628	353,628
Net returns above TVC	145,764	458,439	291,364	718,564
Profit margin (%)	31	56	47	69

Source: Field Data (2024)

For the model examining the effect of subsidies profitability, VIF values similarly remained low (1.305–1.483) with corresponding tolerance values above 0.674, again confirming that the predictors were independent of each other and would yield reliable coefficient estimates.

Table 6. *Estimates of Multicollinearity Statistics.*

Model	Multicollinearity statistics	
Subsidy against profitability		
Received fertilizer subsidies	0.755	1.325
Price of fertilizer subsidies	0.705	1.419
Types of subsidized fertilizers	0.766	1.305
Quantity of subsidized fertilizers received	0.729	1.372
Received seed subsidies	0.755	1.325
Frequency of seeds subsidies	0.674	1.483
Price of seeds subsidies	0.705	1.419
Types of subsidized seeds	0.766	1.305
Quantity of subsidized potato received	0.738	1.356
Received fertilizer and seed subsidies	0.695	1.438

3.5.2. Estimates of Influence of Agricultural Input Subsidy on Irish Potato Profitability

The multiple linear regression model presented in Table 7 was used to assess the influence of agricultural input subsidies on the profitability of Irish potato farming among smallholder farmers in Marakwet West Sub-county. The model showed strong explanatory power, with an R Square value of 0.678 and an Adjusted R Square of 0.667, meaning that about 66.7% of the variation in profitability was explained by the subsidy-related variables. The model was statistically significant, as confirmed by the F-statistic value of 34.418 and a p-value less than 0.01, indicating that the input subsidy factors collectively had a significant impact on profitability.

Several variables emerged as significant predictors. The quantity of subsidized fertilizers received had a positive and significant effect on profitability ($\beta = 0.645$, $p = 0.010$), indicating that higher fertilizer allocations led to increased returns from potato farming. Additionally, receiving subsidized seeds was strongly associated with higher profitability ($\beta = 0.742$, $p < 0.001$), suggesting that access to quality seeds significantly enhances net farm income. Notably, the combined receipt of both fertilizer and seed subsidies was the most influential variable ($\beta = 1.112$, $p < 0.001$), implying that bundled support programs significantly improve profitability by up to 111.2%.

On the other hand, the price of subsidized seeds showed a significant negative relationship with profitability ($\beta = -0.296$, $p = 0.034$), highlighting that reductions in input costs especially seeds can enhance economic returns. Other variables, such as receipt of subsidized fertilizer alone, price of fertilizer, and type or frequency of input subsidies, were statistically insignificant ($p > 0.05$), indicating that these factors had limited influence in isolation.

Table 7. *Estimated results of the influence of agricultural input subsidies on Irish potato profitability among smallholder farmers in Marakwet West Sub-County.*

Regression Statistics					
Model summary					
Multiple R	0.823				
R Square	0.678				
Adjusted R Square	0.667				
Observations	326				
Standard Error	2.585				
ANOVA	SS	df	MS	F	*P*-value
Regression	21459.794	10	2145.979	34.4179	<0.01
Residual	19640.466	315	62.351		
Total	41100.260	326			
	Unstandardized Coefficients		Standardized Coefficients	t Stat	*P*-value
	Beta	Std. Error	Beta		
(Constant)	2.222	0.149		2.799	0.000
Received subsidized fertilizer	1.102	1.045	-0.096	-1.447	0.150
Price of subsidized fertilizer	-0.843	0.262	-0.003	-0.037	0.971
Quantity of subsidized fertilizers	0.645	0.441	0.284	2.630	0.010*
Types of fertilizers	0.432	0.453	0.057	0.447	0.350
Received subsidized seeds	0.742	0.461	0.332	3.882	0.000**
Price of subsidized seeds	-0.296	0.194	-0.172	2.083	0.0340**
Quantity of subsidized seeds	-0.001	0.000	0.057	0.359	0.868
Type of subsidized seeds	-0.001	0.000	-0.232	-3.339	0.601
Received fertilizers and seed subsidies	1.112	0.523	0.460	4.586	0.000**

* = significant at 1% level and **=significant at 5%
Source: Author's Computation from Survey Data (2024)

4. Discussion

The results of this study reveal a mixed but generally positive pattern of input subsidy access and utilization among smallholder Irish potato farmers in Marakwet West Sub-county. Fertilizer subsidies reached 58% of farmers, while seed subsidies reached 83%, suggesting a broader emphasis on seed access by the government. The frequency of subsidy receipt was mostly once per year for both inputs, despite two planting seasons annually, implying partial coverage that may limit the potential impact on profitability. This aligns with previous findings in Kenya and Sub-Saharan Africa, where fertilizer and seed subsidy programs often fail to achieve full seasonal coverage due to logistical constraints, funding limitations, and targeting inefficiencies [23, 24].

The average fertilizer used per farmer (584.8 ± 204.5 kg/year) compared to 537.4 ± 138.5 kg/year received under the subsidy program translates to about 91%

coverage, which is relatively high. This high coverage mirrors Malawi's Farm Input Subsidy Program (FISP), which achieved fertilizer coverage rates above 85%, resulting in measurable yield and profit gains in potato and maize systems [25]. Conversely, seed subsidies covered only 72% of annual seed requirements, signaling a partial dependence on either local varieties or market purchases to meet production goals. Similar seed access gaps have been reported in Ethiopian highlands, where potato intensification efforts were limited by insufficient certified seed distribution [26].

The price differential between subsidized and market inputs was substantial: fertilizer was 36% cheaper and seed 32% cheaper than retail prices. Such reductions directly reduce variable production costs and can improve profitability if yield gains are sufficient to offset fixed costs and market price volatility. Comparable effects were observed in Ghana and Rwanda, where potato and maize farmers under 30–50% input price support realized higher margins than non-beneficiaries [27, 28]. However, the predominance of NPK fertilizer (94.2%) and limited Urea or mixed use (5.8% combined) could restrict nutrient diversity and long-term soil fertility gains, an observation also highlighted in Tanzanian potato systems where mono-nutrient reliance constrained sustainable yield responses [29].

The productivity impact of subsidies was clearly demonstrated by the yield differentials observed across farmer categories. Farmers without subsidies harvested an average of 9.8 t/ha, while those accessing both seed and fertilizer subsidies achieved 22 t/ha, more than doubling productivity. Single input subsidies also produced substantial yield gains: fertilizer-only farmers achieved 17.1 t/ha and seed-only farmers 12.9 t/ha. This hierarchy of impact highlights the synergistic effect of combined subsidies, consistent with evidence from Rwanda's Crop Intensification Program, where joint seed-fertilizer support drove the largest yield improvements for potato and maize [30].

Regression analysis reinforced this synergy, as the combined receipt of fertilizer and seed subsidies had the strongest effect on yield ($\beta = 1.315$, $p < 0.001$), while receiving either input individually yielded positive but comparatively lower effects. This pattern aligns with integrated input adoption literature, which emphasizes that yield response is maximized when complementary inputs are applied together [31]. In Marakwet West, the partial coverage of subsidy programs likely dampened the full potential for productivity transformation, mirroring findings from Kenya's earlier National Accelerated Agricultural Input Access Program (NAAIAP), which faced seasonal and geographic distribution gaps [32].

The average yield of 22 t/ha under full subsidy is competitive by regional standards. In Kenyan highland potato belts, yields under optimal input application typically range from 20–30 t/ha, while non-subsidized smallholders average 7–12 t/ha [33]. These results position Marakwet West as capable of reaching commercially viable productivity levels with strategic subsidy support, provided that market and storage systems can absorb and sustain the increased supply.

Profitability outcomes, measured as net returns above total variable costs (TVC) and profit margins, showed a strong positive association with input subsidies. Farmers without any subsidy achieved a modest Ksh 145,764 net return and a 31% profit margin, which, while positive, offers limited resilience against price shocks or input inflation. Fertilizer subsidies nearly tripled net returns (Ksh 458,439; 56% margin), seed subsidies doubled them (Ksh 291,364; 47% margin), and combined subsidies produced Ksh 718,564 with a 69% margin.

These findings align with international evidence that input subsidies can substantially improve profitability if paired with favorable yields and stable market access. In Uganda, integrated potato subsidy pilots increased farm profit margins from 28% to 63% by reducing input costs and boosting marketable yields [34]. Similarly, Rwandan smallholders under joint seed-fertilizer programs achieved up to 70% margin gains, supporting the notion that subsidy profitability is multiplicative when inputs are combined [30]. However, the negative coefficient for subsidized seed price ($\beta = 0.296$, $p = 0.034$) in the profitability regression underscores that price sensitivity is critical. Even subsidized inputs can erode margins if distribution inefficiencies or market fluctuations raise effective acquisition costs. This aligns with Chirwa and Dorward [25], who reported that late delivery and indirect transaction costs often undermine the intended economic impact of African subsidy programs.

The regression model explaining 66.7% of the variation in profitability (Adjusted $R^2 = 0.667$) confirms that subsidy attributes are primary determinants of economic outcomes in smallholder potato farming. The quantity of fertilizers and receipt of subsidized seeds emerged as the most significant positive predictors, validating that volume and access outweigh nominal price reductions in determining profitability. Conversely, variables such as frequency or type of subsidies were statistically insignificant, reflecting that economic impact is driven by quantity and integration, not formality of program design alone.

When compared with other regions, Marakwet West demonstrates a subsidy-profitability trajectory consistent with partial but high-impact coverage. Full subsidy coverage (both inputs) achieves profitability levels similar to Rwandan and Malawian models where smallholders under integrated programs earned 2–4× higher net returns than non-beneficiaries [25, 27]. However, the study also highlights structural weaknesses familiar to many SSA subsidy initiatives: Incomplete seasonal coverage limits the compounding effect of multi-season profitability; dominance of single-nutrient fertilizer (NPK) risks soil nutrient depletion and long-term yield plateaus; and market dependency means high profits rely on stable potato prices, which remain volatile in Kenyan highlands. The results suggest that for sustainable profitability, subsidy programs should prioritize integrated input packages, ensure multi-season delivery, and link farmers to storage and market support to reduce post-harvest losses and price vulnerability.

5. Summary of Key Findings

This study examined the influence of agricultural input subsidies on the profitability of Irish potato production among smallholder farmers in Marakwet West Sub-County. The findings show that access to agricultural input subsidies varies across farmers, with a higher proportion accessing seed subsidies (83%) compared to fertilizer subsidies (58%). Most farmers received subsidized inputs only once per year despite the existence of two production seasons, indicating partial coverage of subsidy programs.

Enterprise budget analysis revealed clear differences in productivity and profitability across subsidy categories. Farmers who did not receive any subsidies recorded the lowest yields and net returns, while those who accessed either fertilizer or seed subsidies achieved higher yields and profitability. The highest performance was observed among farmers who received both fertilizer and seed subsidies, who attained average yields of 22 t/ha, net returns above total variable costs of KSh 718,564, and a profit margin of 69%.

Regression results further confirmed that agricultural input subsidies significantly influence potato profitability. The quantity of subsidized fertilizers received, access to subsidized seeds, and the combined receipt of fertilizer and seed subsidies were positive and statistically significant predictors of profitability. In contrast, higher prices of subsidized seeds were negatively associated with profitability, underscoring the importance of affordable input delivery.

6. Conclusions

The study concludes that agricultural input subsidies play a critical role in enhancing the profitability of Irish potato production among smallholder farmers in Marakwet West Sub-County. In particular, integrated access to both fertilizer and certified seed subsidies produces a synergistic effect that substantially increases yields and net farm returns compared to single-input or non-subsidy scenarios. These findings demonstrate that bundled subsidy programs are more effective than isolated interventions in improving smallholder farm profitability.

However, the study also finds that the effectiveness of subsidy programs is constrained by partial coverage and limited frequency of input distribution. Most farmers do not receive subsidized inputs for both production seasons, which reduces the potential cumulative benefits of the program. Profitability is also highly sensitive to the quantity and price of subsidized inputs, especially seed prices, suggesting that even subsidized inputs can erode net returns if costs remain relatively high or delivery is delayed.

Overall, while agricultural input subsidies significantly improve productivity and profitability, their impact depends on timely delivery, adequate input quantities, and complementary market conditions that allow increased production to translate into sustainable income gains.

7. Recommendations

Based on the findings of this study, it is recommended that agricultural input subsidy programs in Marakwet West Sub-County prioritize the provision of integrated fertilizer and certified seed packages to maximize productivity and profitability outcomes. Input distribution should be conducted in a timely and multiseasonal manner to align with the two major planting seasons, ensuring that farmers can fully benefit from the subsidy program.

The study further recommends increasing the quantities of subsidized inputs to better match farmers’ production needs, particularly for certified seed, while maintaining affordable pricing to enhance net returns. Diversification of fertilizer types beyond dominant NPK formulations is also recommended to support balanced soil fertility management and long-term productivity.

In addition, subsidy programs should be complemented with improved market access, post-harvest handling, and transportation infrastructure to reduce losses and protect farmers from price volatility. Finally, continuous monitoring and evaluation of subsidy implementation is recommended to improve targeting, efficiency, and sustainability of agricultural input support programs.

Abbreviations

ANOVA	Analysis of Variance
FAO	Food and Agriculture Organization of the United Nations
IBM	International Business Machines
IJAE	International Journal of Agricultural Economics
KALRO	Kenya Agricultural and Livestock Research Organization
KNBS	Kenya National Bureau of Statistics
KSh	Kenya Shilling
NACOSTI	National Commission for Science, Technology and Innovation
NPK	Nitrogen, Phosphorus, and Potassium
OLS	Ordinary Least Squares
SPSS	Statistical Package for the Social Sciences
SSA	Sub Saharan Africa
TVC	Total Variable Costs
USD	United States Dollar
VIF	Variance Inflation Factor

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Author Contributions

Ben Kibor: Conceptualization, Investigation, Formal Analysis, Writing – original draft, Writing – review & editing

Linnet Gohole: Conceptualization, Data curation, Methodology, Investigation, Supervision

Philip Chemwok: Supervision, Writing – original draft, Writing – review & editing

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Ben Kibor is currently pursuing a master of Philosophy in Agricultural Education and Extension at the University of Eldoret, having successfully completed BSc in Agricultural Extension from the Egerton University in 2014. Recognized for his exceptional contributions, Mr. Kibor worked for 13 years as an extension officer in State Department/Ministry of Agriculture Livestock and Fisheries from 2010 to 2013. Currently he works at the Elgeyo-Marakwet County as the county project coordinator. Kibor is a dedicated agricultural professional with a strong background in Agricultural Extension and Education. He holds a qualification in this field, equipping him with the skills to effectively communicate, disseminate, and implement sustainable farming practices among rural communities. Ben has a passion for improving the livelihoods of smallholder farmers through participatory approaches, capacity building, and community-based agricultural development. His strengths lie in training delivery, farmer empowerment, and mobilization of local resources for agriculture.

Linet Gohole is a dedicated lecturer and researcher in Resource Conservation with a specialization in Agricultural Entomology at the University of Eldoret, Kenya. With a strong academic background in entomology and sustainable agriculture, Prof. Gohole focuses on integrated pest management, biodiversity conservation, and ecological approaches to crop protection. He/she has contributed significantly to research on beneficial insect biodiversity, pest dynamics in agro ecosystems, and the role of indigenous knowledge in sustainable pest control. She is actively involved in training students and farmers on environmentally friendly pest management strategies and has published in reputable peer-reviewed journals. Passionate about sustainable agriculture and climate-smart practices, Prof. Gohole collaborates with national and international stakeholders to promote resilience in smallholder farming systems. At the University of Eldoret, she also mentors postgraduate students and participates in curriculum development aimed at addressing current challenges in agricultural production and natural resource conservation.

Philip Chemwok is a Lecturer in the School of Agriculture and Natural Resources at Moi University in Eldoret, Kenya. Dr. Philip Chemwok is a dedicated academic and researcher at Moi University's School of Agriculture and Natural Resources in Eldoret, Kenya. With a strong foundation in agricultural sciences, he focuses on enhancing sustainable farming practices and natural resource management. Dr. Chemwok is actively involved in teaching, mentoring students, and conducting research that addresses the challenges faced by smallholder farmers in Kenya. His work emphasizes the integration of scientific knowledge with practical applications to improve agricultural productivity and environmental conservation. Through collaboration with local communities and stakeholders, Dr. Chemwok contributes to the development of innovative solutions aimed at achieving food security and sustainable development. His commitment to excellence in education and research has made him a valuable asset to Moi University and the broader agricultural sector in Kenya.

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