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Is Fertilizer Subsidy in the Central Regional Economic Block (CEREB) of Kenya Effective in Socio -Economic Livelihood Improvement Among Smallholder Farmers in the advent of Climate Change? – An Empirical Analysis

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Abstract
Production input subsidies have been provided by governments the world over through time. This is more so in the developed world where most commodities are highly subsidized. In most Sub-Saharan Africa (SAA), subsidies were embraced in the 1970s, 1980s and even the 1990s before structural adjustment programmes led by the World Bank stopped or reduced them due to being unsustainable. With decline in crop productivity and food security, the subsidies were re-introduced into the Sub-Saharan Africa region in the 2000s especially with the Malawi success case. However, due to need for targeting, cost control and avoiding crowding out the private sector, the reintroduced subsidies were smart in terms of targeting. Kenya has been providing fertilizers subsidies to smallholder farmers with increasing investment in the programme after the success case of the National Accelerated Agricultural Inputs Access Programme (NAAIAP) of 2007 for both fertilizer and seed. However, the major subsidy is on fertilizer to make it affordable and accessible to smallholder farmers for increased productivity. The Central Region Economic Block (CEREB) consists of ten of the forty-seven counties in Kenya situated at the center of the country around Mount Kenya. These are counties that produce a lot of food crops and are most of them are fairly highly populated. They use a lot of fertilizers due to poor soils. The study sought to establish the impact of fertilizer subsidies on productivity and livelihood improvement of smallholder farmers in the CEREB region and the moderating effect of climate change on the relationship. The study focused on Sub County Agricultural Officers (SCAOs) and senior government agricultural officers in the counties as the respondents given the critical role they played between the national government and farmers especially in subsidy management. A total of 63 SCAOs were targeted with 30 senior officers (three each from each county agricultural office) using structured questionnaires and interview schedules respectively. Smallholder farmers' use of commercial fertilizers, use of subsidized fertilizers, ease of access, targeting of the recipients of the subsidy and the moderating effect of climate change formed the independent variables while smallholder farmers livelihood improvement was the dependent variable. Inferential and regression analysis using SPSS Version 27 revealed that access of the fertilizer subsidy as and when needed as well as targeting of beneficiary farmers had statistically significant effect on the farmers livelihood improvement. It was concluded that the government needed to streamline the supply side and targeting of fertilizers subsidies to have an impact on smallholder farmer livelihoods improvement.
Key words: Fertilizer subsidy, ease of access, targeting, livelihood improvement
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1. Introduction

The issue of fertilizer subsidies in the world is a highly controversial one especially due to the high cost of implementation and the perceived or real benefits. It is also prone to capture by politicians and, if not implemented well, crowds out private sector input dealers which distorts the market. However, farmers the world over crave for input subsidies even in the developed world where massive subsidies in support of both producers and consumers are offered. Subsidies therefore, wherever implemented put a huge budgetary strain in the economy but become a necessary evil as stakeholders tend to be hooked unto them for their varied reasons. Economists have always opined that subsidies are not good for the economy and distort markets hence the emergence of smart subsidies that are more targeted, implemented in market friendly cautionary methods and with other considerations like agronomics, soil testing, seed technologies and availability of water for irrigation. This is what has driven green revolution in other parts of the world with the Asian countries achieving their own in the nineties and the new millennium. In Sub Saharan Africa, high levels of poverty, small landholdings

resulting from continuous subdivision due to population pressure and dependence on rainfed farming has made subsidies a epicenter of debate on their benefit- cost ratio. However, food security is highly undermined whenever subsidies, especially fertilizers, are not provided to the smallholder farmers. Fertilizer prices are beyond reach of most of the smallholder producers and without subsidies, they would result to very poor productivity or total crop failures due to soil mining from continuous use.

In Kenya, after the structural adjustments programmes implemented in the 1990s and 2000s, fertilizer subsidies found their way back around 2005 into the government budgets as a result of high demand from farmers and low production of staple food. Most of Kenya is either arid or semi-arid with less than 20% of landmass being arable through rainfed farming. Due to climate change, there has been draughts and sometimes floods that cause crop failures with high frequency and severity in the recent past. This has greatly undermined food security and threatened an already fragile socio-economic livelihood of most smallholder producers.

The central region economic block (CEREB), situated around the Mount Kenya and Abandare region, is one of the six regional economic blocks that were formed by county governments to leverage their shared resources, economic potential, and geographical proximity to spur growth. The others include the lake region economic block (LREB), the North Rift Economic Block (NREB), Frontier Counties Development Council (FCDC), Jumuia ya Kaunti za Pwani (JKP), and South East Kenya Economic Block (SEKEB). CEREB consists of ten counties including Kiambu, Muranga, Kirinyaga, Embu, Tharaka Nithi, Meru, Laikipia, Nyandarua, Nyeri and Nakuru.

The use of fertilizers subsidies in the CEREB and their effects on productivity of food crops for food security and socio-economic welfare improvement in the background of climate change was the purpose of this study. The study targeted Sub County Agricultural Officers (SCAOs) as respondents due to the central role they play between the national government, county government and the farmers. Further, the study sought information from the County Government Executive officers in charge of agriculture headed by the County Directors of Agriculture (CDAs) and those in charge of agribusiness and crop production. These senior officers were roped in to corroborate or modify what their officers had indicated. There were a total of sixty-three (63) sub-counties in the region at the time of study.

1.1. History, nature and method of fertilizer subsidies in Africa

The issue of input subsidies has been around in Africa, just like the rest of the world for sometime now. In the 1960s and 1970s, international donors supported the use of universal input subsidies to overcome market failures in input and finance markets (Holden, 2019) but the lessons drawn from those interventions were that the subsidies were ineffective in achieving their stated objectives (Jayne and Rashid, 2013). Welfare economics has long recognized the potential usefulness of subsidies in situations where social benefits of individual actions exceed purely private benefits (due to market failures and externalities) especially in Africa where agriculture faces many such market failures and externalities (Jayne, et al, 2016). Input subsidies especially for fertilizers have been popular among politicians and rural public in many countries while they are controversial among economists, development agents and policy analysts (Holden, 2019). This could explain why in the 1990s, after a successful period of universal subsidies in the 1960s, 1970s and 1080s, the world bank and other development economists introduced structural adjustments programmes especially in Sub Saharan Africa (World bank, 2007) which did away with input subsidies due to introduction of a huge financial burden (Chirwa and Dorward, 2013; Jayne and Rashid, 2013).

Unlike most of the rest of developing countries, Sub Saharan Africa has seemingly failed to realize a Green Revolution as yields of critical food commodities continue to lag behind the rest of the world as do fertilizer application and adoption of modern inputs (Carter, Laajaj, and Yang, 2021). The support to universal input subsidies therefore changed to focus on targeted subsidies popularly known as smart subsidies which were widely adopted across many countries in Sub Saharan Africa. With conditionality and external leverage over agricultural policy in decline, and with the growing recognition of the role of agriculture in the overall economic development, African government in 2003 made a public commitment to increase their support to agriculture through the Maputo Declaration of the African Union (Jayne, et al., 2013) followed by the Abuja Declaration in 2006 which stressed the commitment to increased fertilizer use in general and “Smart” Input Subsidies Programme (ISPs) in particular.

In aiming to overcome past deficiencies in input subsidies, market smart input subsidies were introduced to aimed at targeting small-scale vulnerable farmers who did not use inputs before but expected to find it profitable

to do so, promote private sector development where the private sector procured and distributed the inputs using vouchers, matching grants and loan guarantees, have an exit strategy due to huge financial burden on governments and possible market distortion (Morris et al., 2007; Chirwa and Dorward 2013) and are generally user friendly. Furthermore, starting around 2000, many African governments experienced a relaxation of the constraints on public budgets associated with Highly Indebted Poor Countries (HIPC) debt forgiveness and a shift in international donor support from aid conditionality to budget support. This led to a relaxation of public budget constraints and desire to re-institute politically popular but expensive programmes such as ISPs (Jayne, et al., 2016). Most Sub-Sharan African countries re-introduced subsidies valued at over US$ 1 billion with large scale input subsidy programmes often becoming the centerpiece of agricultural development (Jayne, et al., 2016). By 2010, at least 10 African countries accounting for at least half of he population of Sub-Saharan Africa had adopted subsidies amounting to between US 0.6 billion to 1.0 billion per year representing between 14-26% of public expenditure on agriculture in these countries (Jayne, et al., 2018). Following the new awakening to smart subsidies, in 2016, government budgets allocated to input subsidy programmes in Sub-Saharan Africa ranged between US$ 13 million in Rwanda to US$ 32.6 Million in Kenya (Nguyen, et al., 2023).

1.2. Fertilizer Subsidies in Kenya

In primarily agrarian economies, low levels of inorganic fertilizer use are associated with low crop yields, low rural incomes, and high poverty rates. Agricultural, rural and national economic developments are all constrained by a number of interacting households, local and national poverty and productivity traps (Dorward and Chirwa, 2011). A frequently articulated reason for input subsidies in Africa is that many developed countries have implemented them for decades and built their agricultural sectors and Africa should not be exception. This view assumes that input subsidies in developed countries often contribute to those countries development or that they are effective use of public resources compared to other public investments like Agricultural R&D, farmer education, infrastructural development and irrigation (Jayne, et al, 2016). Motivation for fertilizer subsidy programmes vary but all of them are based on the assumption that the existing levels of fertilizer use are sub optimal or too low caused by households' insufficient access to credit to purchase enough quantities, rural households lack of information about the benefits of using fertilizer, risks arising from loss, weak development of commercial input markets and price volatility in output markets (Jayne, et al., 2016) which are all applicable in Kenya.

Despite that assumptions and challenges, the Kenyan Government has endeavoured to invest in fertilizer subsidy programmes over the years. The introduction of the National Accelerated Inputs Access Programme (NAAIAP) in 2007 which involved issue of fertilizer and seed targeting resource poor farmers through vouchers redeemable at registered agro-dealers' shops, led to increased productivity of maize by 361 Kilograms per 100 Kilograms fertilizer on average compared to Malawi's 165 Kilograms per 100 kilograms of MFISP fertilizer and Zambia's 188 Kilograms per 100 Kilograms of ZFISP fertilizers. However, there was negligible impact on net crop income overall but increased net crop income among the poor (Jayne et al, 2016). In the recent past, allocation of government budget to subsidies in the country has reached an all-time high of US$32.6 million in 2016/2017 (Nguyen et al., 2023) rising to US$ 53.3 million in 2025/26.

The importance and budget attached to the fertilizer subsidies however, has not necessarily translated to productivity improvement and improved livelihoods in the country due to a number of factors. Unclear programme objectives and various implementation problems often prevented most input subsidy programmes from being efficient and effective. The objectives have not been clear as national maize production for food security or increased use of productivity enhancing inputs by poor, smallholder farmers to increase their household food security (Kato and Greely, 2016). However, targeting of smallholder farmers is likely to better serve poverty reduction and is also more likely to promote more widespread use of inputs in the long term when these smaller farmers are persuaded of the gains from use of improved seed and fertilizer because of their learning through the subsidy programme (Kato and Greeley, 2016). Dorward (2009) cautioned countries considering re-introduction of agricultural input subsidies on the potential benefits accruing, the conditions required for those benefits to be realized and possible, very significant pitfalls from ineffective implementation. Among the issues are that subsidies, when successfully applied to overcome market failures have played an important developmental role. They have great potential in contributing to wider growth when applied to production of staple grains with a key contribution to consumers' welfare and real incomes through lowering food prices especially where output markets are developed. Rationing and targeting should be done right for subsidies to be effective although smart subsidies are still subjected to political economy with risks and that agricultural input subsidies are needed in the long term if they have to build farmer knowledge and capital, supply systems and wider economic growth.

1.3. Fertilizer subsidies and climate change in Kenya

Whereas the trio combination of fertilizer responsive modern varieties of crops, irrigation and fertilizers were the main drivers of the Asian Green Revolution (Gulati and Narayanan, 2003), in Kenya and most Sub-Saharan Africa, use of fertilizers subsidies is not matched with other key requirements like adequate water or right technologies like seed to maximize productivity. This has been made worse in the recent past by persistent, frequent and long-lasting draughts that impede rainfed agriculture that is practiced by most smallholder farmers who form the majority (over 75%) of food producers in the country. Roughly, 45% of South Asia's grain crops are under irrigation which typically affords 2-3 cropping seasons per year and relatively stable yield response to fertilizers while by contrast, 96% of Sub-Saharan Africa's cultivated land is rainfed and much of it is in semi-arid areas experiencing frequent water stress (Jayne et al., 2016).

In Kenya, national policies and strategies aimed at combating effects of climate change and food insecurity include Kenya Vision 2030, Green Economy Strategy and Implementation Plan (GESIP 2016-2030), Climate Risk Management Framework (CRMF, 2016), Kenya Rural Development Strategy (KRDS, 2002-2017), Kenya National Social Protection Policy (KNSPP, 2011), National Water Master Plan (NWMP, 2030), National Land Policy (NLP, 2009) and Kenya National Climate Change Response Strategy (NCCRS, 2010). The emphasis in the NCCRS is to prioritize the most vulnerable sectors of the economy like agriculture and food security, water, forestry, rangelands, health, social and physical infrastructure for quick and immediate action while providing explicit measures of addressing climate change in Kenya.

In realization of the critical role fertilizer subsidies play in food productivity enhancement, the Kenya government has subsidized the commodity for smallholder farmers over the years to ensure food security. The challenge has however been the level of the subsidy sometimes being inadequate, the timing of delivery where the fertilizers arrive late even after the onset of rains, bureaucratic processes around the management of the subsidy, targeting of recipients with possibility of the commodity getting into large scale non- deserving farmers, and sometimes, corruption in the value chain. More policies aimed at targeting and resource allocation into the programme need to be implemented to make the subsidy work well for the smallholder farmers (Mutunga, 2023). Even with provision of subsidized fertilizers in the background of recurrent draughts and climate variability, productivity improvement among smallholder Kenyan farmers has remained an elusive mirage. Climate change gets in to distort the equation and aggravate the dire situation encountered by the resource poor producers (Mutunga, 2023).

1.4. Objectives and hypotheses

The objective of this study was to establish empirically, the impact of fertilizer subsidy on smallholder farmers livelihood improvement over the last twenty years by enquiring from the sub county agricultural officers who deal with the farmers directly and corroborating the information or otherwise, through the county headquarters agriculture and agribusiness staff. The specific objectives were whether smallholder farmers livelihood improvement was affected by their use or non-use of commercial fertilizers, whether their livelihood improvement was affected by the fertilizer subsidy, whether targeting of recipients affected livelihood improvement and whether climate change moderated the effect of livelihood improvement of smallholder farmers from the use of subsidized fertilizers. Null hypotheses, based on the objectives, were formulated on the basis that there was no relationship between the current use or non-use of fertilizers on farmers welfare improvement from subsidies, no relationship between smallholder farmers livelihood improvement and government fertilizer subsidies, no relationship between livelihood improvement and targeting of beneficiaries and no effect of climate change on the relationship between farmers livelihood improvement and fertilizer subsidy use. The four hypotheses would then be tested statistically through regression analysis to indicate the impact of subsidies or lack of it on farmers livelihood improvement and the moderating effect of climate change on the relationship.

1.5. Conceptual framework

The conceptual framework was formulated on the basis that a smallholder farmers use of commercial fertilizers at the time was already contributing to their livelihood improvement. Provision of government subsidized fertilizers would enhance farmers use for those already doing it and adoption for those not doing so and that would improve productivity of food crops which would translate to food security and livelihood improvement. Targeting was critical to how the subsidy would be administered and whether it would have an impact on smallholder farmers who was the focus of the subsidy or would be diverted to non-deserving recipients. The

moderating effect of climate change on the relationship between smallholder farmers livelihood improvement from subsides was also conceptualized and tested.

2. Methodology

This research entailed both desk and field survey. Desk survey provided information on the status of input use in the country and particularly insights on the fertilizer subsidy programme of the government over the years. Field survey sought to reach out to respondents in three categories of county head office staff dealing with agriculture, agribusiness and crop production, sub county agricultural officers and ten farmers from each of target sub counties selected through the sub county agricultural officers.

2.1. Target Population

The study aimed at targeting all smallholder farmers in the ten Counties of the Central Region Economic Block (CEREB) of Kenya who were engaged in production of food crops preferably for both home consumption and sale for revenue generation.

2.2. Sampling and sample size

Sampling, a process of selecting a portion of respondents from the population who would be engaged in the research to give an insight on the general behaviour of the larger population, was carried out. Due to the vast geographical area of the study, and the conditions defining the target respondents, the method of sampling most appropriate for the study was multi-stage, purposive (judgmental) geared at getting only persons fulfilling the set criteria to participate.

The ten counties in the CEREB region were taken as defined in CEREB. As at the time of the study, the sub counties were sixty-three but the geographical regions kept on changing with creation of new sub-counties although the study confined to the 63. All the sub-counties were included in the study. From each sub-county, the study targeted respondents from three categories. The first category, being the point of entry into the County, were heads of agricultural activities in the county. This was either the County Director of Agricultural (CDA) or equivalent where the devolved governance structure had established new titles for the officers. The head of agricultural activities in the county, became the entry point for establishing contacts with other target respondents. There were therefore ten heads of agricultural activities in the ten counties targeted by the study. However, by nature of the study being inclined to food security and agribusiness, the county head office was also to provide at least two other officers as respondents preferably, the one in charge of crops and the one in charge of agribusiness. This made target respondents from the counties at least thirty (30) which formed the sample size for the county head office. From the sixty-three (63) sub counties, each sub county agricultural officer (SCAO) was targeted as a respondent. This made the sample size from the sub counties as sixty-three.

2.3. Research instruments

The study employed structured questionnaires for sub county agricultural officers and an interview guide for county heads of agricultural sector. The main focus of the study was the sub county agricultural officers being the link between the farmer and the government on either side. For this category of respondents, the structured questionnaire had three parts, the first part requiring general information like county, sub county, ward, location and respondents name (optional) and duration in the county. The portion also contained the GPS coordinates of the respondents. The second portion under A sought the general economic activities of the sub county. The other portions sought the respondents' opinion on a five-point Likert scale on various issues on the five variables of the study thus; the general use of fertilizer, the government subsidies on fertilizers, ease of access of fertilizer subsidies, targeting of farmer recipients and the mediating variable of climate change. The dependent variable was defined by constructs under category N while A was for land sizes and B, D, F, and H constructs defining independent variables. Statements on numeral J were constructs for mediating role of climate change.

The interview guide for county heads of agricultural section contained general information, specific indicators of the agricultural activities in the county and structured questions based on the objectives of the study. The three target heads of agriculture, crops and agribusiness at the county level were also expected to work open questions and provide short answers to the study questions.

2.4. Data collection method

Data collection entailed reaching out to the various categories of respondents. This was done through the county officers in charge of agricultural activities. For each county, the researcher called the heads of agriculture and arranged for physical visits so as to elaborate on the nature of the study after which a concept document was shared with them detailing albeit very briefly, the nature of study, objectives, methods proposed and target respondents. Accompanying the concept paper were authorizations from the National Council for Science, Technology and Innovation (NACOSTI), and sample questionnaires for the various categories.

During the physical meeting with the county head of agriculture, it was elaborated that the county head of agricultural sector would invite all the sub county agricultural officers into a central place (preferably county offices but sometimes in hotels) where the researcher would explain to them the requirements of the study and take them through the questionnaire and explain the nature and expectations from their participation. During the first such meeting, the researcher took advantage of the experts to improve on the questionnaires which were then edited before being sent for administration. Each sub county agricultural officers then carried hard copies provided by the researcher and the interview guides for the county headquarters staff were shared with them during either the planning meeting or the gathering with the sub county agricultural officers. This meant that every sub-county would be visited at least three times; first time to discuss with the head of agriculture on modalities of bringing together the SCAOs, then the engagement of the SCAOs in a sitting and taking them through the questionnaires and importance of the study and finally, a day for collection of the duly filled in questionnaires. In some instances, more than three visits became necessary due to logistical and other considerations. On a few occasions, for far flung counties like Nakuru and Nyandarua, it became necessary to send duly completed questionnaires as package by public transport companies where they would be picked by the researcher from the nearest town.

2.5. Data analysis

Data from the physical hard copies was entered into excel spreadsheets for each respondent for each sub county and each county. A number of research assistants, more specifically students on attachment or internship, were used to enter the data into spreadsheets. Each questionnaire was converted into an electronic form for ease of data entry which was then shared with the assistants. After data entry, the data was converted into data sets for each of the sub county agricultural officers. Each dataset was then subjected to regression analysis. Quantitative data was analyzed using Statistical Package for Social Sciences Version 27 while qualitative data was analyzed using Stata.

2.5.1. Regression analysis

Data was first subjected to preliminary confirmatory tests for eligibility for regression analysis. These included tests of linearity, normality, autocorrelation, multicollinearity and heteroscedasticity to confirm that the data was amenable to regression analysis. Regression was carried out at three stages- first stage was simple linear regression for each independent variable against the dependent variable, second for multivariate regression of all independent variables against the dependent variable and finally the mediating variable was tested on the effects of the relation between the dependent and the independent variables singly and in a multivariate scenario. All regression analysis yielded the various results like model summaries, ANOVA tables and multivariate data tables. Interpretation of the results for each variable in each category of analysis was carried out and discussions done.

2.6. Ethical considerations in data collection

To ensure all requisite procedures were followed in data collection involving members of the public, ethical consent was sought from the university research ethics board and granted. An application was made to the National Council for Science, Technology and Innovation (NACOSTI) and granted which enabled government officers release information that was even thought sensitive but in the safety that the same had been authorized by the regulatory agency. The researcher had also worked with the government (public service) for over two decades including in the ministry of agriculture in the agribusiness department at head office which gave him a strong background on the working of government and having signed the oath of secrecy during the working life and upon retiring from the government, was well positioned to handle government and other sensitive information. This further emboldened the government officers in the knowledge that they were dealing with one of their own and could safely release the requisite information without fear of it ending in the wrong hands. To ensure further safety of the data both in hard and soft copies, all the hard copies were secured under lockable

cabinets in the lead researchers office and soft copies only shared with those who had to know on limited case by case basis. The data was thus secured from any form of interference or loss.

3. Results and Discussion

The Likert scale entries, being ordinal were corrected for analysis by dividing the five intervals from 1-5 and getting 4 which was divided into 5 to get 0.8. This was added to each of the discrete numbers to get the positions from Strongly disagree which was 1 +0.8 to 1.8, Disagree moving from 1.8 to 2.6, Neutral moving from 2.6 to 3.4, Agree moving from 3.4 to 4.2 and Strongly agree moving from 4.2 to 5. Using this scale, descriptive statistics generated from the analysis were interpreted.

3.1. Reasons for use or non-use of commercial fertilizers by farmers

On independent variable A on whether farmers were using commercial fertilizers or not and the reasons for the same, the results showed that respondents agreed except on A1: Lack of knowledge as a reason for none use of fertilizers (Mean = 2.41, Standard Deviation (SD) = 1.371) in the disagree region and for (A5: low quality of fertilizers (mean = 3.31, SD=0.994) meaning that quality of fertilizers was not an issue (Table 1).

Table 1. Reasons why farmers do not use commercial fertilizers

STATEMENT	N	Min	Max	Mean	Std. Deviation
A1: Lack of knowledge on benefits	39	1	5	2.41	1.371
A2: Embraced fertilizers due to training and high yields	39	3	5	4.31	.521
A3: Uses fertilizer but cost is high/prohibitive	39	1	5	4.21	1.218
A4: Lack of access when needed	39	1	5	4.03	.873
A5: Quality is low and discourages usage	39	1	5	3.31	.922
A6: The packages are large for farmers small land sizes	39	1	5	3.54	1.295
A7: The cost is too high, unaffordable	39	1	5	3.51	1.144
Valid N (listwise)	39				

From Table 1, it can be deduced that the Sub County Agricultural Officers (SCAOs) agreed that farmers had embraced use of commercial fertilizers due to the training and the high yields associated with it (B2: Mean=4.31, SD= 0.521), that the farmers used fertilizers although the cost was high and sometimes prohibitive (B3: Mean = 4.21, SD = 1.218), that farmers failed to use fertilizers due to lack of access when needed (B4: Mean =4.03, SD = 0.873), that the packages were large for farmers with small land sized (B6: Mean = 3.54, SD = 1.295) and finally, the SCAOs agreed that cost of commercial fertilizers was too high and unaffordable (B7: Mean =3.51. SD = 1.144). The Senior government officers opinions did not differ with those of the SCAOs as they corroborated the findings.

On cost of fertilizers, studies have shown that adoption of fertilizer use is low even when profitable (Duflo et al., 2011) and evidence exists that under high input and low output prices, fertilizer use is only marginally profitable in many places in Kenya (Marenya & Barrett, 2009). The other major cost consideration in the overall fertilizer subsidy programmes is cost of administration of the subsidy at national level. On top of the potential problem of diversion of public resources associated with fertilizer subsidy programme, widespread anecdotal reports suggest governments and fertilizer import companies may collude to over-invoice the cost of delivering the fertilizer to designated supply points (Jayne et al., 2016). A study by Shimeles, Gurara, and Tessema (2015) who examined fertilizer-retail import price gap in 14 African countries between 2002 and 2013 found the price differentials between the retail and the world market price was negatively correlated with measures of government effectiveness. A study in Kenya showed that substantially larger crowding out effects were likely due to the fact that the country's private sector fertilizer markets were already well developed and the majority of farmers were already using fertilizers prior to the re-introduction of fertilizer subsidies (Jayne et al., 2016)

3.2. Provision of Government Subsidized Fertilizers

This variable sought to establish the status of government fertilizer subsidies in the sub counties. Most respondents agreed with the statements (Mean >3.4) except for statement D3: that subsidized fertilizers were available as and when needed which they strongly disagreed with. The findings are shown in Table 2.

Table 2. Provision of Government Subsidized Fertilizers

STATEMENT	N	Min.	Max.	Mean	Std. Deviation
B1: Government has been providing subsidized fertilizers over the years	39	1	5	3.38	1.206
B2: Subsidized fertilizers has enabled use by smallholder farmers	39	1	5	3.62	.847
B3: Subsidized fertilizers are available as and when needed	39	1	5	1.97	.903
B4: Distribution of subsidized fertilizers is systematic without discrimination	39	1	5	3.49	1.048
B5: There is a policy and system of ensuring subsidies reach intended farmer	39	1	5	3.41	1.141
Valid N (listwise)	39				

Provision of fertilizer subsidies by many governments in Africa has been characterized by mixed fortunes and reactions. However, the general consensus is that most smallholder farmers especially those depending on rainfed farming cannot do without fertilizers much as they cannot afford the price of commercial ones. This is why governments have to step in and provide subsidized fertilizers as a public good, sometimes consuming massive resources on public purse. In Kenya, expenses on fertilizer subsidies have been reported to the tune of US$ 53.3 million in 2025/26 financial year (Agriculture and Food Authority (AFA), Kenya, 2025.

3.3. Ease of access of Subsidized Fertilizers

On ease of access, respondents agreed with the statements except for C5: Subsidized fertilizer was not reliable since it did not come every season (Mean = 3.21, SD =1.08) and that there was corruption at points of delivery, C6 (Mean =2.77, SD =1.158) and that there was quota allocation which was followed and was beyond reproach C7: (Mean = 2.9, SD = 1.071). That there was corruption which militated against farmers getting subsidized fertilizers was also opposed by the SCAOs, D8 (Mean =2.62, SD = 1.067. Respondents agreed or strongly agreed with the rest of the statements describing the administration of government subsidized fertilizers for ease of access by smallholder farmers (Table 3). Analysis of responses from the county crops and county agribusiness officer concurred with those of the SCAOs.

Table 3. Ease of Access of Government Subsidized Fertilizers

STATEMENT	N	Min.	Max.	Mean	S.D.
C1: Government subsidized fertilizers not available and adequate when available	39	1	5	3.77	1.266
C2: Subsidized fertilizers not available in time and come after rains	39	1	5	3.46	1.047
C3: Subsidized fertilizers distributed is encumbered with red tape, inefficiency	39	1	5	3.46	1.097
C4: Subsidized fertilizers are often inadequate and get finished	39	1	5	3.72	.999
C5: Subsidized fertilizers are not reliable since they do not come every season	39	1	5	3.21	1.080
C6: There is corruption at point of delivery where large scale farmers get at expense of smallholder farmers	39	1	5	2.77	1.158
C7: There is quota allocation which is followed and beyond reproach	39	1	5	2.90	1.071
C8: There is corruption which militates against smallholder farmers getting subsidized fertilizers	39	1	5	2.62	1.067
C9: Farmers who live far from distribution points often do not access subsidized fertilizers	39	2	5	4.03	.959

C10: There is need to increase distribution centers within the sub-counties	39	2	5	4.72	.647
Valid N (listwise)	39				

3.4. Targeting Beneficiaries of Government Subsidized Fertilizers

Targeting of beneficiaries is normally a controversial issue because many unscrupulous government officers circumvent the process and issue subsidies to not target groups. The Government of Kenya has devised methods of registering farmers and their land holding by size to ensure targeting. Farmers get electronic messages on the amount of fertilizer allocated to them which they take to the depots and pay the balance on subsidy to get their share. Sometimes, when inadequate quantities are available, rationing is done at the point of distribution and so the farmer does not necessarily get what they have been allocated. On targeting, the SCAOs were in agreement with most of the statements except three (D2, D3 and D6). Table 4 shows the findings on targeting beneficiaries of fertilizers subsidy. There was no divergence of opinion between the SCAOS and responses by senior government officers.

Table 4. Targeting beneficiaries of fertilizer subsidies

STATEMENT	N	Min.	Max.	Mean	S.D.
D1: The Government has an elaborate mechanism of targeting beneficiaries	39	1	5	3.44	1.071
D2: The Government subsidizes fertilizer across the board hence targeting is not necessary	39	1	5	2.72	1.297
D3: Subsidies are sometimes targeted at some special crops which are being promoted by government	39	1	5	3.28	1.276
D4: Food crops are given preference in Government subsidized fertilizers	39	1	5	3.54	1.072
D5: Elaborate registration process prevents non target beneficiaries from getting the subsidized fertilizers	39	1	5	3.67	1.108
D6: The government has developed measures to curb misallocation	39	1	5	2.95	1.169
D7: Registration of farmers ensures smooth identification for allocation	39	1	5	3.67	1.199
D8: Unscrupulous business access subsidized fertilizers and sell at inflated prices	39	1	5	3.41	.910
D9: Some farmers access their allocation and sell to others at inflated prices	39	1	5	3.36	.932
D10: Distribution to the last mile has been a major hindrance to far flung farmers getting the subsidized fertilizers	39	1	5	3.69	1.280
Valid N (listwise)	39				

The assertion that the government subsidizes fertilizers across the board hence targeting is not necessary (D2) was disputed (Mean=2.72, SD =1.297) because this is not the practice in Kenya. Fertilizers subsidies are targeted to smallholder producers and not across the board or for all crops. Registration ensures that they are the ones who receive. The assertion that subsidies are targeted to some special crops did not received agreement among respondents because the fertilizer subsidy is mainly for food crops in general and for smallholder farmers. However, close proximity to agreeing with the statement meant some respondents were almost of the opinion D3: (Mean =3.28, SD =1.267). D6 on government developing measures to curb misallocation did not get a nod from the sub county agricultural officers due to the fact that misallocation still occurs even at distribution centers. The only sure allocation is on the electronic messages but this allocation is seldom honoured since demand always outstrips supply at distribution depots. Table 4 shows how the SCAOs agreed with the rest of the statements describing the nature of targeting of the subsidized fertilizers.

Targeting of beneficiaries of fertilizer subsidies has been widely studies due to its critical role in reaching out resource poor smallholder producers with the subsidized fertilizer and preventing its diversion to those who can afford commercial fertilizers. Kenya's NAAIAP programme targeted smallholder farmers while Malawi's Farm Input Subsidy Programme (FISP) and Zambia's Farmer Inputs Support Programme (ZFISP) all had exclusion or inclusion criteria in their targeting of beneficiaries (Ricker-Gilbert, Jayne and Chirwa, 2011; Mason, Jayne, and Mofya-Mukula, 2013; Sheahan et al., 2014).

3.5. Effects of Climate Change on Production and Productivity

Even with subsidized fertilizers, other necessary conditions for production and productivity must be provided for farmers to realize the gains. Kenya is a water scarce country and irrigation, especially for food crops is highly undeveloped. This means that most of the food crop production is rainfed. Climate change has negatively impacted food production in the recent past due to draughts and floods. On effects of climate change, the responses from the SCAOS are as shown in Table 5.

Table 5. Effects of Climate Change on Use of Subsidized Fertilizers for Productivity

STATEMENT	N	Min.	Max.	Mean	S. D.
E1: Climate change has had profound effects on productivity over the last 20 years despite government efforts at subsidizing fertilizers	39	1	5	4.33	.927
E2: Climate change has made subsidized fertilizers untenable due to extremes (droughts or floods)	39	1	5	3.28	1.337
E3: Effects of climate change are mild in most years hence subsidized fertilizers are still tenable	39	1	5	3.56	1.046
E4: Effects of climate change destroy over 30% of crops every year	39	1	5	3.82	.854
E5: Government has been able to cushion farmers from effects of climate change hence subsidized fertilizers are still tenable	39	1	5	2.97	1.287
E6: There is no control of floods or draughts hence no need for subsidized fertilizers	39	1	4	2.21	1.080
E7: It is difficult to assess effects of subsidized fertilizers due to climate change which has adversely affected production in the last twenty years.	39	1	5	2.82	1.073
E8: Draughts and floods have become more severe and frequent recently hence subsidized fertilizers have no significant impact	39	1	5	2.87	1.056
E9: Government intervention to cushion farmers from effects of climate change through insurance has taken root hence subsidies make sense	39	1	4	2.33	1.155
E10: Government support through subsidized fertilizers is unreliable and erratic hence difficult to apportion its impact	39	1	5	3.13	1.281
Valid N (listwise)	39				

From the findings, the respondents disagreed with most constructs on climate change and its effects on productivity even given the government subsidized fertilizers except for three statements E1, E3 and E4. That Climate change has had profound effects on productivity over the last 20 years despite government efforts at subsidizing fertilizers (E1) was not in doubt as supported by the SCAOs (Mean =4.33 for strongly agree, SD =0.927). On E3 that effects of climate change are sometimes mild and subsidized fertilizers are still tenable got a nod from the SCAOs and rightfully so because not all the counties in the CEREB are greatly adversely affected by rain shortage due to the central location near Mount Kenya which is itself an object of attracting relief rainfall. Only one or two counties and peripheries of a few others (probably another two) are prone to severe draughts and sometimes floods. On effects of climate change destroying over 30% of crops every year (E4) getting strong support by SCAOs was by sheer fact that most seasons experience crop failure in one or two of the CEREB counties. These crop failures sometimes even exceed 50% or even total (100%) failure. All other statements on climate change were rejected by the respondents as they did not depict the truth on the ground.

3.6. Effect of Subsidized Fertilizers on Smallholder Farmers' Livelihood Improvement

The dependent variable of the study was on impact of subsidized fertilizers on productivity of food crops on their socio-economic livelihoods' improvement even in the background of climate change. Table 6 shows the results.

Table 6. Effects of subsidized fertilizers on smallholder farmers livelihood improvement

STATEMENT	N	Min.	Max.	Mean	S. D.
F1: No clear distinction on livelihood changes of smallholder farmer from use of subsidized fertilizers	39	1	5	2.62	1.248
F2: Impact of subsidized fertilizers on productivity, food security and farmer welfare is clearly discernible	39	1	4	3.10	1.021
F3: Farmers livelihoods have been positively impacted by adoption of subsidized fertilizers	39	1	5	3.67	.838
F4: Farmers who use subsidies have been able to increase productivity and educate their children from farming	39	1	5	3.72	.826
F5: Due to subsidized fertilizers, smallholder farmers have been able to build houses and acquire social amenities like telephones, televisions, etc	39	1	4	3.18	.885
F6: Use of subsidies has led to improved food security among smallholder farmers	39	1	5	3.72	.857
F7: Use of subsidies has led to other socio-economic improvements like trade and savings	39	1	5	3.72	.857
F8: Smallholder farmers are fully aware of the benefits of subsidized fertilizers due to the livelihood improvements they have experienced	39	1	5	3.82	.885
Valid N (listwise)	39				

From Table 6, it is evident that the SCAOs agreed with most of the statements on farmers livelihood improvement from use of subsidized fertilizers except for F1, F2 and F5. On F1, respondents disagreed with the assertion that there was no clear distinction on livelihood changes of smallholder farmers from subsidized fertilizer use meaning that they had observed and knew that the subsidized fertilizers had positively impacted farmers livelihood and family welfare. On whether the impact was clearly discernible on productivity, food security and farmer welfare, the respondents did not agree meaning that some felt that the effect was not so pronounced. On whether due to subsidized fertilizers, smallholder farmers had been able to build houses and acquire social amenities like telephones, television sets and others, this did not get support from the SCAOs meaning farmers livelihood changes especially on housing could probably not be attributed to the fertilizer subsidy alone. The SCAOs agreed to the other statements on farmers livelihood improvements as a result of subsidized fertilizers meaning the impact was substantial and positive.

The findings corroborated those of Jayne et al., (2016) that input subsidy programmes could reduce the national poverty rate and, more specifically, the notoriously stubborn rural poverty rates although little empirical evidence existed on this assertion. This study sought and established such evidence. Further evidence has shown that receipt of subsidized fertilizers raises beneficiary household's crop yields and production levels, at least during the year of introduction (Jayne et al., 2016). Holden (2019) argued that fertilizer subsidies have primarily been driven by market failures and recovery after draughts (climate change) causing food shortages hence the primary arguments for scaling up such subsidy programmes.

3.7. Regression Analysis

Both bivariate and multivariate regression analysis was carried out to establish relationships between independent and the dependent variables. Prior to regression analysis diagnostic tests were carried out. Thus;

3.7.1. Diagnostic tests

3.7.1.1. Test of normality

Results revealed that the independent variables passed the normality test with Shaphiro Wilks statistics being over 0.05 as shown in Table 7. However, the dependent variable failed the normality test with a value of 0.003 for Kolmogorov-Smirnov and 0.000 for Shaphiro-Wilks.

Table 7: Tests for Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Y	.178	39	.003	.871	39	.000
X1	.113	39	.200*	.944	39	.053
X2	.154	39	.020	.946	39	.059
X3	.146	39	.035	.967	39	.305
X4	.115	39	.200*	.980	39	.686
Z	.105	39	.200*	.981	39	.735

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

3.7.1.2. Multicollinearity test

Table 8., Linearity tests

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	X1	.878	1.139
	X2	.691	1.447
	X3	.707	1.414
	X4	.927	1.079
	Z	.655	1.526

From the table, it shows that all variables had P-values greater than 0.05 showing absence of collinearity. The other tests for collinearity is the Tolerance and Variance Inflation Factors (VIF) with indicators being tolerance values less than 0.1 indicating multicollinearity and VIF factors greater than 10. The results show absence of multicollinearity. Multicollinearity arises when there is a high degree of correlation among two or more independent variables within a regression model. This makes it difficult to obtain reliable estimates for each variable's individual coefficients. As a result, one variable can be accurately predicted by the others, potentially leading to a multicollinearity. The effectiveness and interpretability of the model may be compromised (Cooper & Schindler, 2014). Imperfect multicollinearity typically results in poorly defined regression coefficients, as well as exaggerated or even infinite standard errors and confidence intervals for each predictor. This can impact the accuracy of accepting or rejecting the null hypothesis.

3.7.1.3. Autocorrelation test

Test for autocorrelation is determined using Durbin-Watson statistic which has a value range of 1 to 4, showing a lack of autocorrelation. Table 9 shows the results of the test.

Table 9. Test of autocorrelation

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.498[a]	.248	.134	.57419	2.622

a. Predictors: (Constant), Z, X_4, X_1, X_3, X_2
b. Dependent Variable: Y

With a value of 2.622 which is within the desired range, there was absence of autocorrelation.

3.7.2. Logistic Regression

Following failure of normality test on the dependent variable, normal multivariate regression could not be carried out. Variables were adjusted into two categories of those who agreed, mean above 3.4 assigned value (1)

and those who disagreed, mean below 3.4 assigned value (0). Logistic regression was then carried out and results presented in Table 10.

Table 10. Model fitness

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	12.856	8	.117

Using the Hosmer and Lemeshow test for model fitness, results indicated that the model was a good fit with P (0.117) greater than 0.05. The amount of variation explained by the model was 21.6 percent as shown by the Negelkerke value, Table 11.

Table 11. Model Summary

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	46.559[a]	.161	.216

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

3.7.3. Logistic Regression without moderating variable

The model was formulated on the basis that smallholder farmers livelihood improvement from government subsidized fertilizers would be a function of their current use of fertilizers, availability of subsidized fertilizer, ease of access by the farmer, targeting of beneficiaries and the moderating effect of climate change. Based on this, four independent variables, one moderating variable and the dependent variables had been defined, thus;

Y = Smallhoder farmers livelihood improvement as a result of using subsidized fertilizer
X_1 = Smallhoder farmers status on use of commercial fertilizers
X_2 = Availability of subsidized fertilizer
X_3 = Ease of Access of the subsidized fertilizer by the smallholder farmer
X_4 = Targeting of beneficiary smallholder farmers
Z = The mediating effect of climate change

Logistic regression results were as shown in Table 12.

Table 12. Logistic regression results for independent variables on the dependent variable

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	X_1	-.447	.598	.559	1	.455	.640
	X_2	1.306	.718	3.312	1	.049	3.691
	X_3	.474	.758	.391	1	.532	1.606
	X_4	1.454	.859	2.867	1	.052	4.282
	Constant	-8.740	4.938	3.133	1	.077	.000

a. Variable(s) entered on step 1: X1, X2, X3, X4.

From the table, it can be deduced that two of the independent variables were significant. X_2 representing availability of subsidized fertilizers and X_4 representing targeting of beneficiaries although X_4 was slightly above 0.05. The results imply that availability of government subsidized fertilizers and the targeting of beneficiaries were the most critical factors leading to whether the smallholder farmer would get the input and improve their productivity and by extension, their welfare or not. Lack of proper targeting has been attributed to sub-optimal use of fertilizers by smallholder farmers due to diversion. In their study both in Malawi and Zambia, comparing the official subsidized fertilizer distribution volumes and the estimated volume of subsidized fertilizer received by farmers according to nationally representative survey data suggested that there was a diversion of 25-35% of

subsidized fertilizer with programme implementers receiving a major portion of benefit rather than farmers (Jayne et al., 2015).

3.7.4. Moderating effects of climate change

Introduction of moderating effect of climate change into the regression gave the following model summary (Table 13).

Table 13. Model Summary for logistical regression with moderator

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	46.557[a]	.161	.216

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Note that the Negelkerke square (R^2) did not change much neither did the Hosmer and Lemeshow test (Table 14) for variance explained by the model and the model fit respectively. It means that the moderator had little effect on the outcome of the regression.

Table 14. Test of goodness of fit with moderation

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	12.888	8	.116

Explaining the Variation
Table 15 shows the model variables after introduction of the moderator.

Table 15. Logistic regression results with moderator

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	X_1	-.450	.602	.559	1	.455	.638
	X_2	1.290	.796	2.629	1	.105	3.633
	X_3	.460	.815	.319	1	.572	1.584
	X_4	1.446	.878	2.710	1	.100	4.246
	Z	.045	.970	.002	1	.963	1.046
	Constant	-8.742	4.939	3.133	1	.077	.000

a. Variable(s) entered on step 1: X_1, X_2, X_3, X_4, Z.

Introduction of the moderator led to most variables, even those originally significant, being turning out not significant. Further logistic regression was carried out with moderating effect of climate change on each of the independent variables and results of model summary and model fitness are shown in Tables 16 and 17.

Table 16. Regression model summary with moderator on the independent variables

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	37.881[a]	.329	.441

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

From the model summary, the moderating variable was able to raise the level of variation explained by the model from 21.6 percent to 44.1 percent. Table 17 shows the model fitness.

Table 17. Model fitness after introduction of interaction term on all independent variables.

Hosmer and Lemeshow Test			
Step	Chi-square	df	Sig.
1	10.007	8	.265

The model fitness was confirmed by the Hosmer and Lemeshow test as fit (0.265).
Logistic regression results with effects of the moderator on all the independent variables are shown on Table 18.

Table 18. Logistic regression results with moderation of the variables.

		B	S.E.	Wald	df	Sig.
Step 1[a]	X_1	-5.969	7.528	.629	1	.428
	X_2	20.026	11.172	3.213	1	.049
	X_3	-8.061	7.123	1.280	1	.258
	X_4	26.945	12.836	4.406	1	.036
	Z	24.528	14.888	2.714	1	.099
	Z1_C	1.420	2.356	.363	1	.547
	Z2_C	-5.571	3.358	2.752	1	.097
	Z3_C	3.451	2.588	1.779	1	.182
	Z4_C	-7.451	3.743	3.963	1	.047
	Constant	-181.459	102.330	3.144	1	.076

From Table 18, there were clearly effects of interaction of the moderator of climate change on the relationship between the smallholder farmers welfare improvement as a results of using government subsidized fertilizers, ease of access, targeting and whether farmers were using commercial fertilizers or not. The availability of government subsidized fertilizer, X_2 was still significant (0.49) and so was the targeting of beneficiaries X_4 (0.47). Climate change was able to moderate the relationship of smallholder farmers' welfare improvement and targeting of beneficiaries (0.47). Jayne et al., (2016) argue that studies from Africa have tended to emphasize failures in input and credit markets and underemphasize other factors like the declining soil fertility associated with rising land pressures and continuous cultivation, poor soil management practices, and rainfed farming as the limiting conditions for African farmers realization of profitability from fertilizer use. A study in Ethiopia by Mackonnen et al (2018) revealed that farmers who perceived higher risks associated with climate change were more likely to adopt draught tolerant maize varieties compared to those who perceived lower risks. This shows that climate change has been and is a serious consideration in input use and adoption of technologies for improved productivity.

4. Conclusion

The study results revealed that the most critical aspects of government fertilizer subsidy on farmers welfare improvement were the availability of the subsidized fertilizer to the farmers as and when needed and the proper targeting of beneficiary farmers. Fertilizer subsidies in Kenya have not been very timely and arrive late even after onset of rains for the majority of smallholder farmers who rely on rainfed production hence the need for government to improve on timing of issue of subsidies.

Farmers welfare was significantly improved by the use of subsidized fertilizers as was confirmed by the model fit and the level of variation explained. However, there was variability in responses depending on how the SCAOs perceived livelihood improvement with most of them confirming positive livelihood enhancement as a result of fertilizers subsidies improving productivity of especially food staples like maize.
Mediation of climate change was confirmed as significant on the farmers welfare improvement as it moderated on the productivity of food crops despite use of subsidized fertilizers. Climate change has had a profound effect on farming in Sub-Saharan Africa and especially Kenya which is largely (over 80%) semi-arid and arid land. Fertilizer subsidy is greatly undermined by adverse effects of climate change. Climate change mitigation is critical to cushion smallholder farmers from devastating effects of draughts and floods even in the background of giving fertilizer subsidies.

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