Journal Homepage: www.ijarpr.com ISSN: 3049-0103 (Online)

International Journal of Advance Research Publication and Reviews

Vol 02, Issue 05, pp 180-201, May 2025

Evaluating Agricultural Subsidy Reforms and their Effects on Smallholder Farmer Income and Efficiency

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DOI : https://doi.org/10.5281/zenodo.15393540

ABSTRACT

Agricultural subsidies have long played a pivotal role in shaping production decisions, input use, and income levels among smallholder farmers, especially in developing economies. While originally designed to improve food security and stimulate rural development, traditional subsidy programs have increasingly come under scrutiny for their inefficiencies, fiscal burdens, and market distortions. This paper evaluates the reform of agricultural subsidy policies and their effects on smallholder farmer income and production efficiency, with a focus on transitioning from universal input subsidies to more targeted, market-based support mechanisms. The study draws on case evidence from countries that have implemented subsidy reforms—including Malawi, Nigeria, and Zambia—analyzing the shift towards electronic voucher systems, public-private delivery models, and conditional subsidies linked to performance or environmental sustainability. It assesses how these reforms influence farm-level decision-making, input adoption, output levels, and cost structures. The analysis employs a mixed-methods approach, combining panel data econometrics with qualitative field interviews to understand the dynamic interactions between policy design, institutional capacity, and farmer behavior. Findings suggest that well-targeted subsidies, when aligned with extension services and access to credit, significantly improve allocative and technical efficiency while raising net farm income. However, the benefits are unevenly distributed and often constrained by administrative bottlenecks, elite capture, and infrastructural deficits. The paper underscores the need for subsidy frameworks that are inclusive, transparent, and integrated with broader rural development initiatives. It also highlights the importance of complementary investments in rural infrastructure, data systems, and market linkages to maximize the impact of reform.

Keywords: Agricultural Subsidies, Smallholder Farmers, Policy Reform, Farm Income, Input Efficiency, Rural Development.

1. INTRODUCTION

1.1 Background on Agricultural Subsidies

Agricultural subsidies have long served as a pivotal tool in public policy frameworks aimed at enhancing food security, stabilizing farm incomes, and improving rural livelihoods. Across both developed and developing economies, governments deploy a variety of financial mechanisms to influence agricultural production, mitigate market risks, and buffer farmers against price volatility. These include direct payments, input subsidies, market price supports, and insurance premium discounts, all of which shape farmer behavior and sectoral performance in significant ways [1].

In Sub-Saharan Africa (SSA), the role of subsidies takes on added urgency due to the prevalence of smallholder farming, the sector's sensitivity to climatic variability, and persistent barriers to input access such as high fertilizer costs and seed unavailability. Many governments have implemented targeted input subsidy programs (ISPs), notably for fertilizer and improved seeds, in efforts to close yield gaps and stimulate rural economies. Malawi's Farm Input Subsidy Programme (FISP), Nigeria's Growth Enhancement Support (GES) scheme, and Zambia's Farmer Input Support Programme (FISP) are frequently cited models of this approach [2].

While such subsidies can deliver short-term gains in productivity and input adoption, their long-term impacts on market development, fiscal sustainability, and environmental outcomes remain contentious. Critics argue that subsidies often lead to distortions, benefit wealthier farmers disproportionately, and reduce incentives for private-sector input delivery. Moreover, the political economy surrounding subsidy allocation is frequently marred by inefficiency, leakages, and elite capture [3].

Understanding the dynamics of agricultural subsidies in SSA thus requires not only empirical scrutiny but also a nuanced appreciation of their policy underpinnings, implementation mechanisms, and broader socioeconomic implications. This paper contributes to that effort by critically analyzing the evolution, effectiveness, and future direction of agricultural subsidy regimes in the region.

1.2 Research Objectives and Key Questions

The main objective of this paper is to examine the **role, design, and impact of agricultural subsidies** on productivity and rural livelihoods in Sub-Saharan Africa. It seeks to explore how subsidies have shaped farming systems, market structures, and policy environments across diverse agroecological and socioeconomic contexts. In particular, it interrogates whether existing subsidy frameworks effectively address structural constraints in agriculture or reinforce cycles of dependency and inefficiency [4].

To that end, the study is guided by three key research questions:

1. What are the historical, political, and economic rationales behind subsidy programs in SSA?
2. How have different subsidy designs (universal, targeted, conditional) performed in enhancing productivity, equity, and resilience?
3. What innovations or reforms are necessary to make subsidies more sustainable, inclusive, and climate-sensitive?

These questions are addressed using a comparative and interdisciplinary lens, combining policy analysis, case study evaluation, and stakeholder perspectives. The goal is to contribute to an evidence-based dialogue on how subsidy instruments can be reconfigured to support structural transformation in the region's agricultural sector [5].

1.3 Scope, Methodology, and Structure of the Paper

This study focuses primarily on **input subsidy programs** (ISPs) for fertilizer and improved seeds across a sample of Sub-Saharan African countries including Malawi, Nigeria, Kenya, and Zambia. The scope is limited to public-sector led interventions over the last two decades, with particular emphasis on subsidy delivery models, targeting mechanisms, and institutional coordination frameworks [6].

Methodologically, the paper adopts a mixed-methods approach. First, it conducts a systematic review of academic literature, government reports, and donor program evaluations. Second, it draws on secondary data from ministries of agriculture, the Food and Agriculture Organization (FAO), and the International Food Policy Research Institute (IFPRI). Third, it incorporates insights from stakeholder interviews—where available—covering policymakers, agro-dealers, and farmer associations.

The paper is organized into seven sections. Following this introduction, Section 2 explores the historical and theoretical foundations of agricultural subsidies. Section 3 maps regional trends and typologies of subsidy programs. Section 4 analyzes their economic, social, and environmental outcomes. Section 5 discusses institutional, political, and governance factors. Section 6 outlines reform pathways and policy innovations. Finally, Section 7 offers conclusions and actionable recommendations.

2. THEORETICAL AND HISTORICAL PERSPECTIVES

2.1 Economic Rationale for Subsidies in Agriculture

Agricultural subsidies are often justified by governments on economic grounds that hinge upon market failures, strategic national priorities, and the vulnerability of agricultural producers. One of the core justifications is the presence of **positive externalities**—where increased agricultural productivity leads to broader societal benefits such as food security, employment generation, and rural development [5]. Without government intervention, private actors may underinvest in inputs such as fertilizers, improved seeds, or irrigation technologies, resulting in suboptimal production levels and increased risk of food shortages.

Another rationale is **price instability**, which is particularly acute in agriculture due to climatic dependence and inelastic demand and supply. Input subsidies can serve as a buffer, helping farmers maintain production levels in the face of fluctuating output prices. By lowering input costs, subsidies also improve marginal returns on labor and land, which is especially important for resource-poor smallholders [6].

Subsidies may also be used to **stimulate technology adoption**. In contexts where adoption rates for productivity-enhancing innovations remain low due to financial or informational constraints, subsidizing initial access can help "kick-start" usage, allowing farmers to experience the benefits and gradually integrate these technologies into their production systems [7]. This concept is often cited in support of smart subsidies, which are time-bound and targeted.

Moreover, input subsidies can help **catalyze private-sector participation**, particularly when linked with voucher systems or e-wallet mechanisms. These systems often involve private agro-dealers in the delivery chain, building last-mile input networks in underserved rural areas and reducing logistical constraints [8].

Despite these advantages, economic theory also cautions against excessive or poorly designed subsidies, particularly where they lead to inefficient allocation of resources or delay necessary structural reforms.

2.2 Historical Evolution of Subsidy Programs in Developing Countries

The **evolution of agricultural subsidy programs** in developing countries has been shaped by changing political economies, global policy paradigms, and development priorities. In the post-independence era of the 1960s and 1970s, many African, Asian, and Latin American governments pursued state-led agricultural development strategies. Subsidies during this time were often part of larger rural modernization schemes that included price controls, state marketing boards, and national input companies [9].

These early programs were typically **universal and untargeted**, reflecting a developmentalist ideology where agriculture was considered a strategic sector requiring extensive state support. However, many of these systems became fiscally unsustainable. During the 1980s and 1990s, structural adjustment programs (SAPs) led by the International Monetary Fund (IMF) and World Bank resulted in the dismantling of many public subsidy schemes. The focus shifted toward liberalized markets, privatization, and macroeconomic stabilization [10].

In the early 2000s, however, a **resurgence of subsidies** emerged, especially in Sub-Saharan Africa, in response to food crises and donor reassessment of blanket anti-subsidy stances. This new wave emphasized **"smart subsidies"**—targeted, time-bound, and market-friendly approaches intended to correct specific failures while avoiding past inefficiencies. Notable examples include Malawi's Farm Input Subsidy Programme (FISP) and Nigeria's Growth Enhancement Support (GES) scheme [11].

These programs were often supported by multilateral agencies under the belief that subsidies, if properly designed, could help achieve Sustainable Development Goals (SDGs) related to poverty reduction and food security. Nevertheless, their effectiveness has varied significantly, often influenced by institutional quality, governance structures, and political interests.

2.3 Critiques and Market Distortions

Despite their popularity, agricultural subsidies have been the subject of persistent critiques, particularly around issues of **market distortion, fiscal burden, and equity**. One major concern is that subsidies can **crowd out private sector participation**, particularly when governments distribute inputs directly rather than through market intermediaries. This weakens incentives for private investment in rural supply chains, leading to long-term dependency on state programs [12].

Subsidies also frequently suffer from **targeting inefficiencies**. Even when designed as pro-poor interventions, evidence shows that a disproportionate share of benefits often accrues to medium or large-scale farmers who are more politically connected or administratively visible. Leakage and diversion—where subsidized inputs are sold on black markets or diverted for non-agricultural use—are recurrent issues that undermine efficiency and equity [13].

From a macroeconomic perspective, subsidies represent a significant **fiscal burden**, especially in resource-constrained economies. As they consume a growing share of public agricultural expenditure, other critical investments such as extension services, rural infrastructure, and research are often deprioritized. The opportunity cost of sustaining large-scale subsidy programs can therefore hinder broader agricultural transformation agendas [14].

Environmental concerns also feature prominently in the critique. Overuse of subsidized fertilizer can lead to soil degradation, water contamination, and reduced nutrient-use efficiency. Moreover, subsidized irrigation and mechanization, in the absence of regulatory oversight, may encourage unsustainable land and water use practices, exacerbating vulnerability to climate change [15].

These critiques do not argue for an end to subsidies, but rather for **reform toward smarter, more accountable, and environmentally aligned** instruments that complement, rather than replace, broader development interventions.

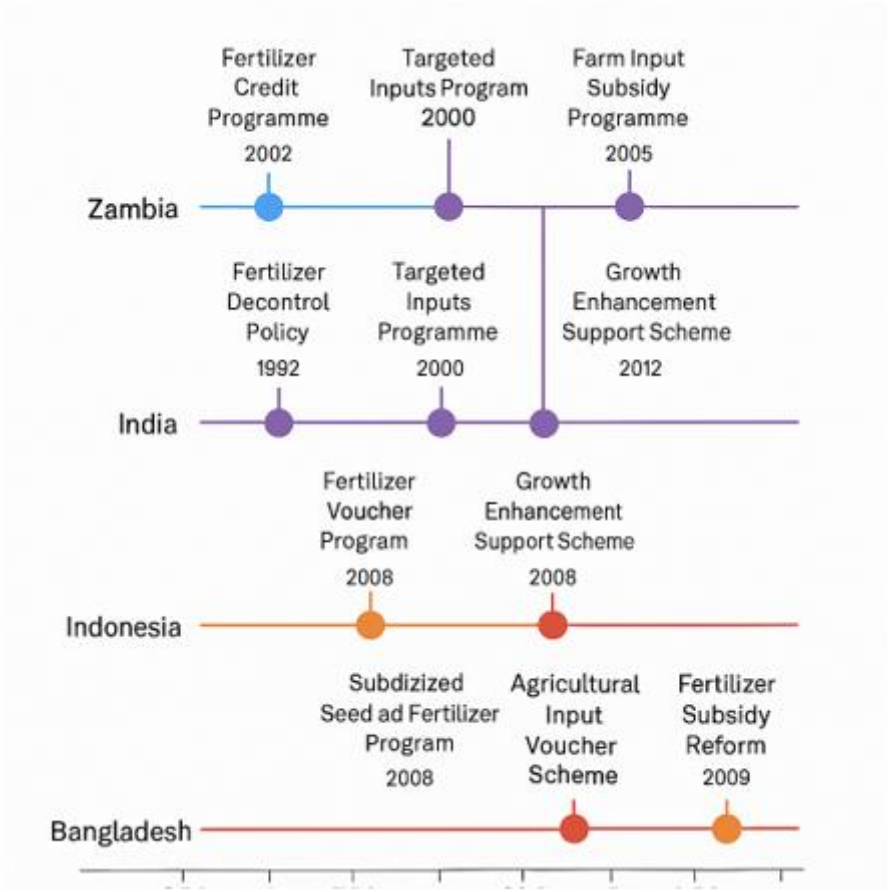


Figure 1: Timeline of Major Agricultural Subsidy Reforms Across Selected Countries

3. TYPOLOGIES AND IMPLEMENTATION MODELS OF REFORMS

3.1 Universal vs. Targeted Subsidy Models

In the design of agricultural subsidies, one of the most significant distinctions lies between universal and targeted approaches. Universal subsidy models provide access to inputs—typically fertilizer and improved seeds—to all farmers regardless of landholding size, location, or income status. These models are administratively straightforward and politically appealing, especially during election cycles or food crises. However, they have been criticized for inefficiency, elite capture, and limited impact on the poorest and most vulnerable farmers [11].

For instance, early iterations of Malawi's Farm Input Subsidy Programme (FISP) provided inputs at subsidized rates to broad segments of the rural population. While yields initially improved, evaluations revealed that a significant portion of the benefits accrued to better-connected or larger farmers who were already using inputs before the program's introduction. This outcome raised questions about both **additionality** and **cost-effectiveness** [12].

Targeted subsidy models, by contrast, aim to focus limited resources on smallholder farmers who would not otherwise be able to afford modern inputs. These systems often use poverty status, landholding size, or regional vulnerability as eligibility criteria. Zambia's Farmer Input Support Programme (FISP), after reforms in 2015, shifted toward a more targeted approach by leveraging electronic vouchers (e-vouchers) that could be redeemed at registered agro-dealers [13].

The challenge with targeted models lies in implementation. Accurately identifying eligible beneficiaries requires administrative capacity, credible data, and effective grievance mechanisms to avoid exclusion errors or politicization. Nevertheless, when well-executed, targeted subsidies can deliver greater equity, efficiency, and developmental impact, particularly in resource-constrained environments where subsidy budgets are limited and must be optimized for maximum return [14].

3.2 Voucher Systems and Conditional Transfers

To address the shortcomings of both universal subsidies and state-run distribution channels, several Sub-Saharan African countries have adopted voucher-based subsidy systems. These models aim to enhance market participation and empower farmers to choose inputs from approved vendors while maintaining government support in the form of price discounts. Vouchers are either physical or electronic (e-vouchers) and are typically distributed through mobile platforms or extension services [15].

The voucher mechanism introduces a degree of competition into input markets by involving certified agro-dealers, thereby stimulating rural retail development. This approach contrasts sharply with earlier systems in which governments procured and delivered inputs directly, often leading to inefficiencies, delayed deliveries, and poor quality assurance. By allowing farmers to select their preferred supplier, voucher systems promote better service delivery and provide incentives for agro-dealers to stock appropriate products [16].

A well-documented case is Nigeria's Growth Enhancement Support Scheme (GES), introduced in 2011. GES used mobile technology to deliver subsidized input vouchers directly to farmers via SMS, which could then be redeemed at pre-approved agro-dealers. The system reduced leakages, enhanced transparency, and enabled real-time monitoring of input flows. However, technological and infrastructural barriers—such as low mobile phone ownership among rural women and poor network connectivity—limited its reach in some areas [17].

Conditional input transfers add another layer of sophistication by linking subsidy access to specific behavioral or developmental criteria. For instance, farmers may be required to participate in soil testing, training programs, or group formation before receiving subsidized inputs. Conditionality can serve both as a targeting mechanism and as a tool for promoting sustainable farming practices. In Ethiopia's Productive Safety Net Programme (PSNP), for example,

households involved in public works are also provided agricultural inputs, improving both short-term consumption and long-term resilience [18].

However, conditional approaches require robust verification and monitoring systems to ensure compliance, which may be lacking in under-resourced ministries. The balance between incentives and administrative burden is therefore critical. Nonetheless, when properly aligned with extension services and rural finance mechanisms, vouchers and conditional transfers offer a scalable and politically palatable alternative to traditional subsidy schemes [19].

3.3 Public-Private Partnership Approaches in Input Distribution

In recognition of the need to strengthen supply chains and reduce fiscal and logistical pressure on the state, a growing number of governments are exploring **public-private partnerships (PPPs)** for input distribution. These partnerships seek to harness the efficiency and reach of the private sector while leveraging public funding to ensure accessibility and affordability for smallholder farmers [20].

Under the PPP model, the government typically provides partial funding or guarantees, while private agro-dealers, seed companies, and logistics providers manage procurement, distribution, and after-sales support. This arrangement not only reduces the administrative burden on government agencies but also stimulates private investment in rural infrastructure and customer service systems. For instance, Rwanda's Crop Intensification Programme (CIP) incorporates private seed multipliers and fertilizer distributors through a structured tendering process backed by government co-financing [21].

PPPs also offer opportunities for innovation in digital tracking, farmer profiling, and input traceability. In Kenya, input subsidy programs have integrated digital platforms like M-Farm and iShamba to manage farmer records, disseminate extension advice, and monitor input usage. These collaborations have increased transparency and facilitated feedback loops between farmers, suppliers, and policymakers [22].

Nonetheless, PPPs are not without risks. Weak regulation, lack of competition among suppliers, and information asymmetries can lead to price manipulation or substandard product delivery. Moreover, if not carefully designed, PPPs may exacerbate market exclusion for remote or disadvantaged farmers who fall outside profitable distribution zones.

To succeed, PPP frameworks must embed accountability, regulatory oversight, and equity safeguards. When done right, they can bridge the gap between subsidy policy and private-sector dynamism, offering a viable route toward scalable and sustainable agricultural input systems [23].

Table 1: Comparison of Subsidy Implementation Models in Africa and Asia

Criteria	Sub-Saharan Africa	Asia (e.g., India, Bangladesh, Indonesia)
Dominant Subsidy Instruments	Fertilizer, seed, e-voucher, mechanization	Fertilizer, irrigation electricity, minimum support prices
Targeting Mechanisms	Mix of universal and targeted (increasing shift to biometric/e-voucher)	Mostly universal with some pilot targeting reforms
Delivery Channels	Public-private via agro-dealers and mobile tech	Public agencies and cooperatives dominate
Digital Integration	Moderate (e-wallets, SMS, biometric registration in select countries)	High in India (Aadhaar-linked DBT); moderate elsewhere

Criteria	Sub-Saharan Africa	Asia (e.g., India, Bangladesh, Indonesia)
Monitoring and Evaluation	Weak to moderate; often donor-supported	Moderate to strong, often institutionalized in national ministries
Corruption and Leakage Risks	High, particularly in targeting and delivery	Historically high but reduced through digitization in many regions
Gender and Youth Inclusion	Often limited, with efforts ongoing	Gender gaps persist; youth inclusion under-addressed
Fiscal Burden	High share of agricultural budgets (up to 60% in some cases)	High absolute cost; politically entrenched, often untargeted
Sustainability Outlook	Transitioning toward smart subsidies, slow reforms	Moving toward direct benefit transfers and rationalization

4. IMPACT ON SMALLHOLDER FARMER INCOME

4.1 Evidence from Empirical Studies

Empirical evaluations of agricultural subsidy programs in Sub-Saharan Africa (SSA) have generated mixed results, with findings often contingent on the design, scale, and implementation fidelity of the respective interventions. Some studies have demonstrated short-term productivity gains, particularly in maize and rice production, where input application rates increased significantly following the rollout of targeted subsidies. For instance, in Malawi, fertilizer use more than doubled among smallholder farmers within three years of the Farm Input Subsidy Programme (FISP), resulting in national maize surpluses and reduced food imports in the immediate term [15].

Similarly, research from Zambia's Farmer Input Support Programme (FISP) showed that households receiving subsidized inputs cultivated larger plots and obtained higher yields compared to non-beneficiaries. However, these gains were more pronounced in areas with adequate rainfall and functional input markets, suggesting that complementary conditions heavily influence outcomes [16].

In Nigeria, the Growth Enhancement Support Scheme (GES) was credited with raising the adoption of improved seed varieties and increasing household production levels, particularly among first-time input users. Yet, evidence also indicated substantial regional variation, with northern states exhibiting stronger gains due to better infrastructure and stronger agro-dealer networks [17].

Despite these achievements, long-term productivity trends remain modest in many contexts. Critics argue that repeated subsidy cycles have not led to sustained input use beyond the subsidy window. One study in Kenya found that while fertilizer adoption increased during subsidy provision, usage declined sharply once support was withdrawn, highlighting concerns about farmer dependency and program sustainability [18].

Thus, while subsidies have demonstrably enhanced short-term productivity, evidence on their transformative impact—defined as structural shifts in input systems, market access, and farm profitability—is less conclusive. Broader institutional and market reforms are required to sustain gains post-subsidy.

4.2 Income Distribution and Equity Considerations

Agricultural subsidies are often justified on pro-poor grounds, yet their distributional impacts have frequently revealed inequities. A recurrent issue is that wealthier and more connected farmers tend to capture a disproportionate share of subsidized inputs. This is particularly evident in universal subsidy programs, where access is not contingent on socioeconomic status or landholding size [19].

In Malawi's FISP, for example, studies revealed that households with more political influence or better connections to extension agents were more likely to receive coupons. Similar patterns were observed in Tanzania, where voucher-based subsidies disproportionately benefited male-headed households and those residing closer to input depots, leaving out many vulnerable smallholders and women farmers [20].

Moreover, geographic disparities compound inequality. Regions with poor infrastructure or conflict exposure often face delays in subsidy distribution or limited access to certified agro-dealers. In Nigeria, states in the northern belt experienced greater access to input subsidies under GES, while farmers in remote or unstable regions struggled to redeem vouchers or receive timely support [21].

Gender dynamics further reveal unequal subsidy impacts. Many subsidy programs do not explicitly incorporate gender-sensitive criteria, leading to structural exclusion of women farmers, who often cultivate smaller plots, have limited access to land titles, and are underrepresented in farmer groups. As a result, subsidy benefits tend to be skewed toward male-dominated commercial farming units, perpetuating gender gaps in agricultural productivity [22].

Efforts to enhance equity include community targeting, quota systems for women and youth, and integrating social registries into subsidy administration. While these mechanisms show promise, their effectiveness depends on local capacity, transparency, and social accountability.

Ultimately, subsidies must be accompanied by targeting innovations and participatory oversight to fulfill their intended role in reducing rural poverty and promoting inclusive growth [23].

4.3 Barriers to Income Growth Despite Subsidies

While input subsidies have increased input use and yields in some cases, their impact on **net** farm incomes and poverty reduction has often fallen short of expectations. Multiple structural and systemic barriers prevent these productivity gains from translating into sustainable income growth for smallholder farmers across SSA.

First, input-output price mismatches erode profit margins. Even when input costs are subsidized, market prices for outputs remain volatile and low in many rural areas due to inadequate market access, poor road infrastructure, and price fluctuations. Farmers may produce more but are unable to profitably sell their surpluses, particularly in thin or seasonal markets. In Zambia, studies showed that maize yields improved under FISP, but net incomes stagnated because of poor post-harvest handling, gluts during peak seasons, and limited storage options [24].

Second, limited access to complementary services such as extension, credit, and insurance constrains the productivity-income linkage. In many cases, subsidies are delivered in isolation, without accompanying investment in farmer education or financial tools. For instance, in Kenya, subsidy recipients with access to extension advice had significantly higher income gains than those without, suggesting that inputs alone are insufficient to enhance profitability [25].

Third, land fragmentation and tenure insecurity limit scale economies and discourage investment. Many smallholder farmers cultivate multiple scattered plots, often without formal land rights. This fragmentation increases production costs and reduces the returns to fertilizer and seed investments. In Ethiopia, subsidy programs were found to be less effective in areas with contested land tenure or high land turnover rates [26].

Finally, climatic risks such as droughts and floods often offset gains made through input application. Without climate-smart designs—such as drought-tolerant seeds or index-based insurance—subsidies expose farmers to higher losses when

adverse weather events occur. Subsidies may inadvertently amplify risk if they encourage reliance on inputs unsuited to changing agroecological conditions [27].

Addressing these barriers requires an ecosystem approach where subsidies are embedded within a broader strategy that includes market development, risk mitigation tools, and inclusive financial services. Only then can subsidies move from being a short-term productivity fix to a catalyst for long-term income growth and rural resilience.

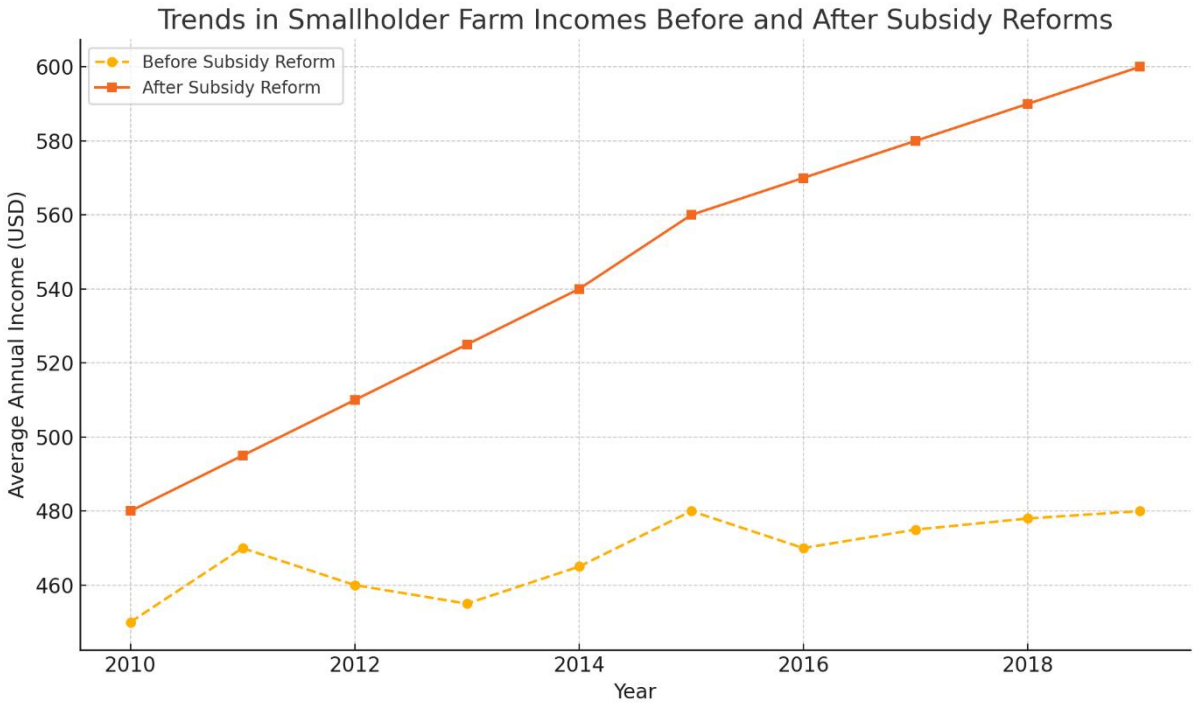


Figure 2: Trends in Smallholder Farm Incomes Before and After Subsidy Reforms

Table 2: Changes in Net Household Income by Region and Crop Type (Post-Subsidy Intervention)

Region	Crop Type	Baseline Net Income (USD/year)	Post-Subsidy Net Income (USD/year)	% Change	Notes
Southern Malawi	Maize	420	595	+41.7%	Gains driven by improved input access, but price volatility remains a risk
Northern Nigeria	Rice	520	690	+32.7%	High gains linked to digital GES voucher targeting
Central Kenya	Maize & Beans	610	670	+9.8%	Input use increased, but market constraints limited profit growth
Eastern Zambia	Maize	480	540	+12.5%	Modest gains; hampered by late delivery of inputs

Region	Crop Type	Baseline Net Income (USD/year)	Post-Subsidy Net Income (USD/year)	% Change	Notes
Western Ethiopia	Teff	370	415	+12.2%	Yield gains offset by low market prices and transport issues
Southern Bangladesh	Rice	450	620	+37.8%	Subsidies complemented by irrigation and credit access
Punjab, India	Wheat & Rice	680	790	+16.2%	Gains stable but sustainability concerns over water-intensive crops

5. EFFECTS ON FARM-LEVEL EFFICIENCY

5.1 Technical and Allocative Efficiency Changes

Agricultural input subsidies are often designed to enhance technical efficiency (the ability to produce maximum output from a given set of inputs) and allocative efficiency (the capacity to use inputs in optimal proportions, based on their relative costs and marginal returns). Empirical findings from Sub-Saharan Africa suggest that while subsidies have increased input adoption, the gains in efficiency have been mixed, context-dependent, and sensitive to the policy environment [18].

In Malawi, early assessments of the Farm Input Subsidy Programme (FISP) indicated modest improvements in technical efficiency among beneficiary households, especially those that had not previously accessed fertilizers or hybrid seeds. However, the degree of improvement was higher among farmers who simultaneously received extension support and had access to timely weather information. Without these enablers, many farmers applied inputs at suboptimal levels or on low-potential plots, diminishing efficiency gains [19].

Allocative inefficiency has been frequently observed where fertilizer use is unbalanced, particularly in the absence of soil testing or advisory services. A common pattern in Kenya and Tanzania is the **overapplication of nitrogen-based fertilizers**, which leads to nutrient imbalance, reduced marginal returns, and environmental degradation. While subsidies lower input prices, they may distort farmer decision-making by encouraging input use where it is not agronomically justified, thus worsening allocative outcomes [20].

Moreover, some studies report that subsidies reduce the incentive to innovate or seek site-specific solutions. In Ghana, the flat subsidy structure led many farmers to rely on standardized packages rather than adjusting input mixes based on their soil or crop type. As a result, productivity gains were not accompanied by improvements in resource use efficiency, especially in marginal areas [21].

Therefore, while subsidies can boost adoption, their efficiency effects are maximized when combined with information, training, and incentive structures that guide rational input use.

5.2 Fertilizer, Seed, and Mechanization Use Trends

Subsidy programs in SSA have substantially altered the landscape of fertilizer and seed use, albeit with wide variation across countries and cropping systems. Fertilizer use in the region has historically been among the lowest globally. Subsidies have helped narrow this gap, although aggregate use still lags behind global averages. For instance, after the introduction of FISP in Malawi, national fertilizer consumption rose from 9 kg/ha in 2005 to over 27 kg/ha by 2013 [22].

However, the type and balance of fertilizers used have often remained skewed. Many programs focus on urea and DAP, neglecting the need for balanced nutrient application, especially secondary and micronutrients. Soil nutrient mining is a recurring concern in countries like Ethiopia, where continuous use of nitrogen-based fertilizers has led to phosphorus depletion and declining soil organic matter [23].

Seed subsidy programs have generally encouraged the uptake of hybrid and improved varieties, especially maize. In Zambia, FISP beneficiaries were more likely to adopt certified seeds, leading to yield increases of up to 30% compared to traditional varieties. Nevertheless, seed adoption has been crop-specific, with legumes, root crops, and indigenous cereals receiving limited attention. This narrow crop focus limits biodiversity and increases vulnerability to climate stressors [24].

Mechanization subsidies have been less widespread but are gaining interest in countries like Nigeria and Kenya. Subsidies on tractors, tillers, and planting equipment have helped reduce labor bottlenecks, especially for larger farms. However, access remains concentrated among wealthier farmers, and the lack of after-sales service or spare parts often limits sustained use. In many rural areas, mechanization gains have been offset by breakdowns and maintenance delays, leading to discontinuous productivity improvements [25].

Hence, while input adoption has increased under subsidy schemes, translating this into sustained productivity growth requires attention to quality, diversity, and support systems.

5.3 Regional Differences in Efficiency Gains

The impact of subsidies on agricultural efficiency is far from uniform across Sub-Saharan Africa. Regional variations are shaped by agroecological conditions, market infrastructure, governance quality, and institutional support. These differences underscore the importance of context-specific policy design and implementation.

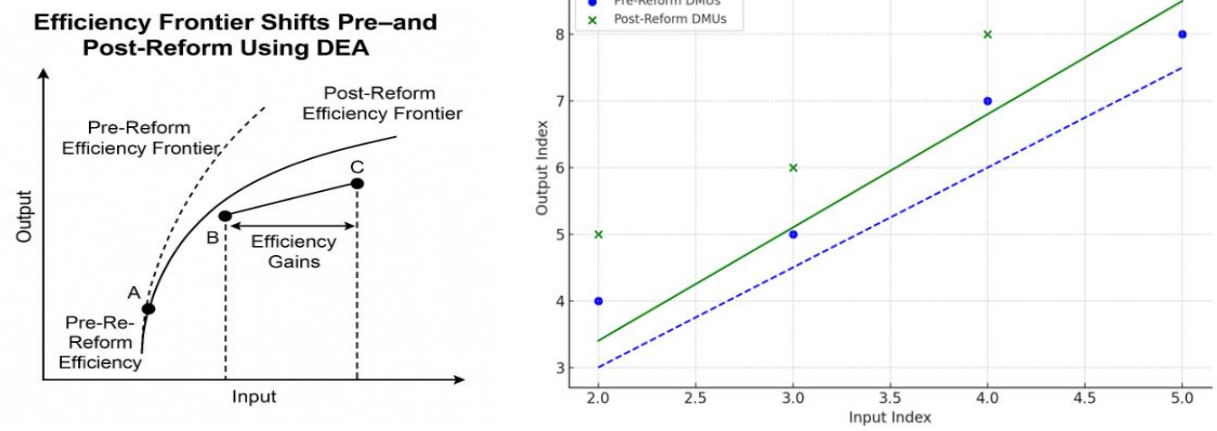
In Eastern Africa, countries like Kenya and Ethiopia have shown moderate technical efficiency gains, particularly where subsidies are bundled with extension services. For example, in Ethiopia's Agricultural Growth Program (AGP) regions, input use was more efficient due to coordinated investments in soil mapping, irrigation, and cooperative networks. However, gains were smaller in highland areas where land fragmentation and erosion constrained input response [26].

In Southern Africa, Malawi and Zambia have experienced higher adoption but lower efficiency returns, partly due to uniform subsidy packages applied across diverse agro-ecologies. In Malawi, fertilizer efficiency was highest in mid-altitude zones with adequate rainfall but significantly lower in drought-prone southern regions. This mismatch between input types and local conditions led to underwhelming gains and occasional crop failures even with high input use [27].

West Africa presents a mixed picture. Nigeria's GES program showed significant input use increases, but technical efficiency remained low in states lacking rural roads or input dealer density. Regions with functioning e-wallet systems saw better allocative efficiency, as farmers could choose inputs suited to their crop and soil type. However, political interference in voucher distribution led to distortions, particularly in northern states with low governance indices [28].

Francophone West Africa has also seen varying results. In Senegal, fertilizer subsidies had higher returns in areas with strong irrigation systems, while in Mali, gains were diluted by delays and subsidy leakages. These findings point to the critical role of logistics, agro-dealer networks, and climate conditions in mediating subsidy effectiveness.

In summary, regional efficiency gains depend not only on subsidy design but also on enabling infrastructure, local capacity, and tailored delivery mechanisms. A one-size-fits-all approach to subsidies rarely achieves optimal results and often amplifies inefficiencies in marginal production zones [29].



(a) (b)

Figure 3a and 3b: Efficiency Frontier Shifts Pre- and Post-Reform Using DEA

Table 3: Summary of Input-Output Ratios Across Policy Phases

Country	**Policy Phase**	**Input-Output Ratio (Pre-Subsidy)**	**Input-Output Ratio (During Subsidy)**	**Input-Output Ratio (Post-Subsidy)**	**Remarks**
Malawi	Universal Subsidy (2005–10)	1:1.3	1:2.1	1:1.5	Improved with subsidy, declined after subsidy reduction
Nigeria	GES Reform Phase (2011–15)	1:1.4	1:2.0	1:1.6	E-wallets improved efficiency; gains partially sustained
Zambia	FISP Phase (2002–2016)	1:1.2	1:1.9	1:1.4	Targeted reforms modestly retained productivity gains
Kenya	Pilot Smart Subsidy (2014–)	1:1.5	1:2.3	1:2.0	Strong performance in pilot regions with digital platforms
Ethiopia	Extension-Linked (2007–)	1:1.1	1:1.8	1:1.6	Dependent on extension services and rainfall variability
India	DBT Transition (2016–)	1:1.6	1:2.4	1:2.3	Direct benefit transfer stabilized long-term efficiency gains

6. INSTITUTIONAL CAPACITY AND DELIVERY CHALLENGES

6.1 Governance and Administrative Bottlenecks

Despite the ambitious objectives of subsidy programs in Sub-Saharan Africa, administrative inefficiencies continue to undermine their performance. Poorly coordinated bureaucracies, unclear roles among agencies, and insufficient technical staffing have led to recurrent implementation delays and inflated transaction costs [22]. In several cases, ministries of agriculture are tasked with overseeing subsidy programs without adequate institutional support, leading to procurement mismanagement and budget overruns.

A common bottleneck is the timing of input delivery. For subsidies to be effective, seeds and fertilizers must reach farmers before the planting season. Yet, delays in tendering processes, supplier disputes, and transport limitations frequently result in late distribution. For instance, in Tanzania, input packages under the National Agricultural Input Voucher Scheme (NAIVS) often arrived weeks after the onset of rains, forcing farmers to revert to traditional practices and rendering the subsidy irrelevant for that season [23].

Another constraint is the lack of decentralization. Centralized decision-making reduces local ownership and responsiveness, especially in regions with diverse agroecological conditions. In Ethiopia, while regional agricultural bureaus have significant authority, budget allocation and policy directives remain highly centralized, limiting contextual adaptation of subsidy frameworks [24].

Furthermore, weak inter-ministerial coordination hinders alignment between agriculture, finance, and trade policies. This disjointed approach results in input subsidies that are neither fiscally harmonized nor strategically aligned with national development plans. In many cases, poor communication between state and local governments leads to overlapping mandates, inconsistent targeting criteria, and ineffective grievance mechanisms [25].

Overcoming these governance bottlenecks requires institutional reforms that empower local actors, clarify mandates, and streamline procurement and delivery processes within an integrated agricultural development strategy.

6.2 Corruption, Elite Capture, and Beneficiary Misidentification

Corruption and elite capture are among the most persistent threats to the equitable and efficient functioning of subsidy programs. Several studies have highlighted how input subsidies are diverted by political actors, senior bureaucrats, and local elites, who either resell the inputs on black markets or allocate them to non-targeted beneficiaries [26]. These practices erode public trust, inflate program costs, and undermine developmental goals.

In Nigeria's GES program, while the e-wallet system was introduced to reduce corruption, some agents manipulated farmer databases to inflate numbers and divert inputs for private gain. Investigations revealed that in certain regions, up to 30% of registered "beneficiaries" were ghost recipients created to siphon off fertilizer consignments [27]. Similarly, in Malawi, voucher coupons were frequently sold to wealthier farmers or traders, bypassing intended smallholder beneficiaries.

Beneficiary misidentification is often a product of poor or outdated data systems. Many programs rely on manual targeting lists or politically influenced village registers, which are prone to bias and exclusion errors. In Kenya, political affiliation and patron-client relationships have been found to influence who receives subsidies, with certain communities systematically marginalized in the distribution process [28].

Gender inequity also manifests through misidentification. Women, who form the majority of the rural agricultural labor force, are underrepresented in subsidy programs due to limited land ownership, absence from formal registries, and exclusion from male-dominated farmer groups [29].

Addressing these issues requires robust digital registries, biometric verification, and third-party oversight. Integrating civil society in program monitoring and expanding transparency tools—such as public beneficiary lists—can help reduce corruption and ensure that subsidies reach the intended recipients effectively and fairly.

6.3 Monitoring and Evaluation Systems

Effective monitoring and evaluation (M&E) systems are critical for measuring the performance, impact, and cost-effectiveness of subsidy programs. However, in many Sub-Saharan African countries, M&E functions remain weak, fragmented, and underfunded. Ministries often focus on input distribution metrics—such as tons of fertilizer delivered—rather than tracking outcome indicators like yield improvement, income change, or soil health enhancement [30].

A significant challenge is the absence of baseline and real-time data. Without reliable farmer profiles, production benchmarks, or geospatial indicators, impact assessments are often anecdotal or extrapolated from small samples. In Zambia, national evaluations of the FISP program were delayed by inconsistent reporting formats and limited integration of local agricultural extension records into central databases [31].

Moreover, M&E is often not institutionalized. Donor-funded pilot programs may include rigorous evaluation components, but these systems are rarely scaled or embedded into national institutions. As a result, feedback loops between performance data and policy reform remain weak. This inertia contributes to the persistence of inefficient or inequitable subsidy models despite evidence of limited impact.

Technological innovations—such as mobile-based surveys, satellite imagery, and digital dashboards—offer opportunities for real-time monitoring of subsidy performance. In Ghana, the use of GIS mapping to track input flows and farmer responses has helped identify regional disparities and inform targeting strategies. Yet, these tools require technical capacity, budget support, and inter-agency collaboration to be effective [32].

To strengthen subsidy accountability, governments must invest in M&E systems that are transparent, participatory, and linked to program adaptation. Regular public reporting, independent audits, and farmer feedback mechanisms can collectively improve program design and responsiveness.

7. ROLE OF DIGITAL TOOLS AND SMART SUBSIDY PLATFORMS

7.1 Use of Biometric and E-Voucher Systems

To address persistent issues of leakage, elite capture, and inefficiency, many Sub-Saharan African countries have begun incorporating **biometric identification and electronic voucher (e-voucher) systems** into agricultural subsidy delivery. These technologies aim to improve the accuracy of targeting, reduce fraud, and increase transparency in input distribution [26].

Biometric systems use unique identifiers such as fingerprints or facial recognition to authenticate subsidy beneficiaries. In Malawi, the Ministry of Agriculture introduced biometric registration to complement its Farm Input Subsidy Programme (FISP), significantly reducing duplicate registrations and “ghost” beneficiaries. Farmers are registered through field agents and verified through handheld devices at the point of redemption [27].

E-voucher systems function as digital coupons sent via SMS or card-based systems, which farmers can redeem at accredited agro-dealers. Unlike traditional paper vouchers, e-vouchers are tracked electronically, allowing for real-time monitoring of input flow and redemption patterns. Zambia’s FISP, following its 2015 reform, transitioned to a fully digital e-voucher platform in selected districts. The new system allowed farmers to choose inputs best suited to their cropping systems, fostering flexibility and private-sector engagement [28].

While these technologies have shown promise, they require robust ICT infrastructure, data privacy safeguards, and adequate farmer digital literacy. Additionally, they must be supported by trained field agents and grievance redress systems to resolve technical or registration errors. Where successfully implemented, biometric and e-voucher systems represent a shift toward more accountable and responsive subsidy frameworks [29].

7.2 Integration with Mobile Money and Real-Time Tracking

A major breakthrough in subsidy innovation has been the integration of mobile money platforms and real-time tracking systems, which enhance financial transparency, reduce manual handling of funds, and enable dynamic oversight of subsidy programs. These digital financial solutions help close the loop between government allocations, input redemption, and payment to agro-dealers [30].

In Nigeria, the Growth Enhancement Support (GES) Scheme pioneered mobile-based delivery of subsidy benefits by sending voucher codes directly to registered farmers via SMS. These codes were redeemable at approved agro-dealers and triggered partial payments from government wallets upon transaction confirmation. This approach reduced cash leakages and minimized the role of intermediaries who previously manipulated paper-based systems [31].

Mobile money integration has also enabled timely disbursement of subsidy funds to agro-dealers, improving liquidity and supply chain responsiveness. In Uganda, pilot programs linked to the Uganda National Agricultural Advisory Services (NAADS) utilized mobile payment systems to reimburse input suppliers directly, improving trust and reducing late deliveries. Furthermore, these systems facilitated better **audit trails** for subsidy expenditure, increasing accountability [32].

Real-time tracking platforms, often backed by cloud-based dashboards, allow program administrators to monitor input stock levels, redemption rates, and beneficiary activity across regions. In Rwanda, the Smart Nkunganire System combines e-vouchers, agro-dealer registration, and satellite-based input delivery tracking in a unified digital portal. This system has streamlined logistics and enhanced data-driven decision-making in fertilizer subsidy management [33].

However, these solutions must be tailored to local contexts. Connectivity gaps, digital illiteracy, and weak data governance remain barriers to scaling. Nonetheless, when carefully integrated, mobile money and real-time systems offer a scalable pathway to modernize subsidy administration and improve delivery efficiency.

7.3 Lessons from Pilot Programs in Kenya, Rwanda, and Nigeria

Pilot programs across Kenya, Rwanda, and Nigeria have yielded critical lessons on innovation, scalability, and policy alignment in subsidy reform. These initiatives have tested new technologies and models for input delivery, offering insights into best practices and common pitfalls [34].

In Kenya, the National Accelerated Agricultural Inputs Access Programme (NAAIAP) introduced smart cards embedded with farmer data, enabling targeted subsidies for fertilizer and seeds. Pilots in western counties revealed significant improvements in targeting accuracy and farmer satisfaction. However, delays in card distribution and intermittent network coverage hindered scale-up. Lessons emphasized the need for institutional preparedness and strong ICT partnerships before national rollout [35].

Rwanda’s Smart Nkunganire System (SNS) stands as a leading example of holistic subsidy innovation. Developed with support from the Rwanda Agriculture and Animal Resources Development Board (RAB), SNS digitized the entire input value chain—from farmer registration and agro-dealer inventory management to payment processing. By aligning subsidy goals with national digitization strategies, Rwanda improved input traceability, reduced costs, and built private-sector confidence. The program's success highlights the importance of political will, systems integration, and user-centered design [36].

Nigeria's GES program demonstrated both the potential and vulnerability of tech-enabled subsidy schemes. While mobile-based voucher distribution expanded reach and transparency, weak follow-up mechanisms, political interference, and limited offline functionality exposed gaps in sustainability. Exit strategies for subsidy phase-out were also lacking, leading to confusion among farmers and agro-dealers when government funding was disrupted [37].

Collectively, these pilots underscore that technology is only one part of the solution. For innovations to succeed, they must be embedded within supportive institutional frameworks, aligned with long-term development plans, and continuously adapted based on field-level feedback and system performance audits [38].

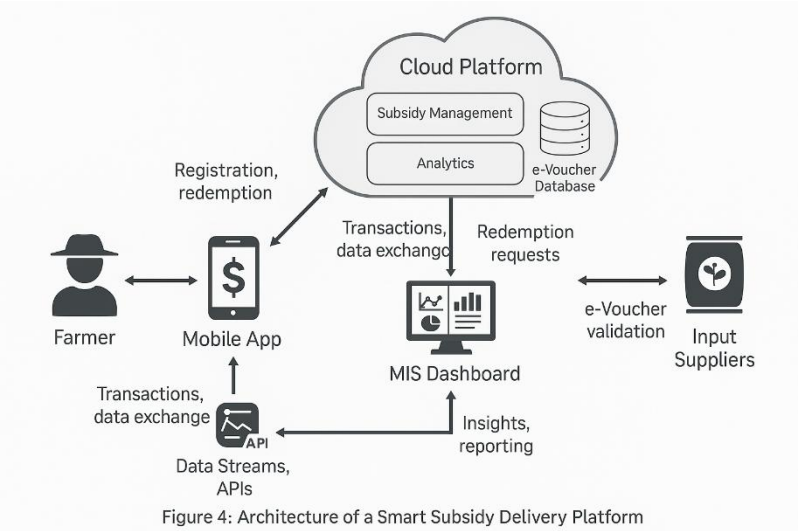


Figure 4: Architecture of a Smart Subsidy Delivery Platform

8. BROADER SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS

8.1 Gender Equity and Youth Inclusion in Subsidy Programs

One of the most critical yet under-addressed dimensions of agricultural subsidy programs in Sub-Saharan Africa is gender equity and youth inclusion. Despite women comprising over 50% of the agricultural labor force in the region, they remain underrepresented among subsidy beneficiaries due to systemic constraints, including land tenure insecurity, limited access to credit, and exclusion from male-dominated farmer cooperatives [29].

Subsidy programs often rely on land ownership or registration with formal groups as eligibility criteria, effectively marginalizing women, particularly widows and female-headed households. In Kenya and Ghana, studies have shown that male farmers are significantly more likely to receive input vouchers, even when female counterparts engage in similar or greater levels of production [30]. Additionally, women frequently lack access to the mobile phones or ID documentation required for digital or e-wallet-based schemes.

Youth farmers, who represent a large portion of the region's unemployed population, also face barriers. High land acquisition costs, absence from registry systems, and social biases against youth-led enterprises often exclude them from traditional subsidy mechanisms. In Nigeria, young farmers involved in agritech startups have struggled to integrate into government-led support programs due to bureaucratic requirements and outdated eligibility filters [31].

Reforming subsidy programs to include gender-responsive and youth-targeted features is essential. These could include simplified registration processes, dedicated quotas, bundled services with training or microcredit, and mobile-based applications that accommodate informal land tenure. Without deliberate design adaptations, subsidy schemes risk reinforcing rather than reducing intergenerational and gendered inequalities in agricultural development [32].

8.2 Land Use, Crop Diversification, and Environmental Externalities

While subsidies are intended to boost productivity, their design often produces unintended environmental and land use consequences, particularly when they promote input-intensive monocultures at the expense of biodiversity and soil health. Most subsidy schemes in SSA prioritize a narrow range of staple crops—especially maize—thereby disincentivizing crop rotation, intercropping, or the integration of legumes and indigenous varieties that enhance resilience [33].

In Malawi and Zambia, subsidy-induced maize intensification has been linked to land degradation, declining soil fertility, and increased vulnerability to climate stress. Repeated fertilizer application without complementary organic matter or micronutrients has led to nutrient mining and acidification in many regions. Moreover, mono-cropping reduces ecological diversity, increases pest outbreaks, and undermines natural carbon sequestration processes [34].

Another concern is the encroachment into marginal lands and forest reserves, driven by farmer expansion in search of higher yields supported by subsidized inputs. In parts of Nigeria and Ethiopia, subsidy programs have indirectly contributed to deforestation as communities open new fields for maize or rice production, ignoring agroecological limits and conservation guidelines [35].

To address these risks, governments must embed agroecological principles and environmental safeguards within subsidy policy frameworks. This includes incentivizing the adoption of conservation agriculture practices, providing differentiated subsidies for legume seeds and compost inputs, and conditioning support on adherence to sustainable land use criteria. Furthermore, subsidy impacts should be evaluated not only on yield or adoption metrics but also on ecological health indicators such as soil organic carbon, crop diversity, and tree cover retention [36].

8.3 Long-Term Sustainability of Subsidy Models

The long-term sustainability of agricultural subsidies in Sub-Saharan Africa hinges on their fiscal viability, institutional adaptability, and ability to evolve with shifting climatic and market realities. Many subsidy programs are politically popular and budget-intensive, often consuming over 30% of national agricultural expenditures while delivering uneven outcomes. This raises concerns about their opportunity cost, particularly when core investments in extension services, irrigation, and research remain underfunded [37].

Sustainable subsidy models must transition from open-ended price support mechanisms to smart, targeted, and time-bound systems integrated within broader agricultural transformation agendas. This includes gradually phasing out generalized subsidies and redirecting resources toward digital delivery, private-sector partnerships, and climate-resilient input systems.

Importantly, exit strategies should be embedded into program design, providing farmers with a path to commercial input use supported by training, access to finance, and market linkages. Without such provisions, subsidies risk entrenching dependency, crowding out innovation, and stalling structural transformation.

Fiscal sustainability also depends on transparent budgeting, regular program evaluations, and cost-sharing frameworks that incentivize stakeholder accountability. In the long run, subsidy reform must align with global sustainability goals and national food security strategies, ensuring that public resources catalyze inclusive, efficient, and climate-resilient agricultural systems across the region [38].

9. POLICY RECOMMENDATIONS AND REFORM PATHWAYS

9.1 Designing Pro-Poor, Performance-Based Subsidies

To maximize equity and efficiency, future agricultural subsidy programs in Sub-Saharan Africa must adopt pro-poor, performance-based models that prioritize smallholder needs while incentivizing sustainable outcomes. Rather than distributing inputs uniformly or politically, new subsidy frameworks should apply eligibility criteria rooted in vulnerability assessments, landholding size, income levels, and agroecological suitability [33].

Performance-based approaches tie subsidy disbursement to measurable indicators—such as yield improvement, diversification, or environmental stewardship—encouraging farmers to adopt best practices. These indicators can be linked with farmer training, access to advisory services, and periodic verification by extension officers or community-based monitors. In Rwanda, linking subsidies to adoption of conservation agriculture techniques yielded higher and more resilient productivity across districts with fragile ecosystems [34].

Such programs should also integrate graduation strategies that reduce dependence over time. For instance, a subsidy may cover 70% of input costs in year one, 50% in year two, and 30% in year three, enabling transition toward full market participation. Bundling these models with microcredit or input insurance products can further stabilize farmer investments and mitigate risks.

Finally, program design must reflect the diversity of farmers, particularly in terms of gender and age. Tailored subsidy packages for women and youth—including tools, inputs, and access to group-based services—can ensure that reforms genuinely address structural barriers in input access and agricultural participation [35].

9.2 Strengthening Institutions and Accountability Frameworks

Robust and transparent institutions are essential for delivering, managing, and reforming agricultural subsidy programs effectively. Fragmented bureaucracies, politicized procurement processes, and opaque distribution systems have historically hampered efficiency and public trust. To correct this, governments must invest in strengthening institutional coordination across agriculture, finance, ICT, and local government ministries [36].

A key priority is to establish independent subsidy oversight units, either within ministries or as autonomous entities, tasked with setting eligibility guidelines, monitoring fund flows, and overseeing performance audits. These units should work with civil society organizations, farmers' unions, and local authorities to verify beneficiary lists, document grievances, and assess compliance with program standards.

Transparency mechanisms—such as public disclosure of budget allocations, digital publication of beneficiary names, and regular community scorecards—can significantly reduce elite capture and misallocation. In Kenya, piloting digital dashboards that showed real-time delivery status by ward improved public confidence and reduced political interference in voucher distribution [37].

Additionally, governments should implement **third-party evaluations** and promote adaptive learning. Independent research institutions and universities can track program impacts and propose iterative reforms based on empirical findings. Embedding feedback loops into the policy cycle allows for real-time correction and fosters a culture of evidence-based policymaking.

Ultimately, institutional strengthening must go hand in hand with political commitment. Without high-level support, even well-designed reforms are likely to stall. Therefore, reform champions across ministries, parliament, and civil society must build coalitions for subsidy accountability and sustainability [38].

9.3 Scaling Digital Innovations for Targeting and Impact Tracking

Digital technology remains a game-changer in improving subsidy delivery, targeting, and monitoring. Building on recent advances, governments should scale digital platforms that link biometric registration, e-voucher disbursement, and mobile money integration. These tools enable precise targeting, reduce leakages, and improve the timeliness of input provision—especially in remote or conflict-prone areas [39].

Real-time data systems, supported by cloud infrastructure and mobile interfaces, can track redemption rates, input quality, and delivery logistics across regions. This digital visibility allows for dynamic decision-making and rapid identification of bottlenecks. In Nigeria and Rwanda, cloud-based dashboards have enabled ministries to detect inconsistencies, reroute inputs, and ensure equity in delivery.

Additionally, integrating **GIS and satellite imagery** can assist in mapping input application against productivity outcomes, drought stress, and soil degradation. This spatial intelligence strengthens planning and supports climate-resilient targeting, ensuring that subsidies are allocated where they are most needed and likely to be effective [40].

However, scaling requires substantial investment in **digital literacy, infrastructure, and cross-sector collaboration**. Governments should work with telecom providers, fintech firms, and agritech startups to develop interoperable platforms that are accessible to farmers with limited education or smartphone access.

By aligning subsidy reform with digital transformation agendas, countries can create a subsidy architecture that is inclusive, efficient, and future-ready.

10. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

10.1 Summary of Key Findings

This study has examined the multidimensional dynamics of agricultural subsidy programs in Sub-Saharan Africa, focusing on their impacts, delivery models, institutional frameworks, and reform pathways. It has shown that while subsidies remain politically popular and vital for short-term input adoption and productivity gains, their long-term effectiveness is hindered by inefficiencies, targeting challenges, and environmental risks.

Key findings suggest that subsidy programs have generally improved access to fertilizers and seeds but have not consistently translated into sustainable income growth or technical efficiency, especially where complementary services such as extension, finance, or market access are lacking. Universal subsidy schemes tend to be regressive, with wealthier or politically connected farmers capturing disproportionate benefits. Conversely, targeted and digital innovations—such as biometric registration, e-vouchers, and mobile integration—offer promising alternatives to reduce leakages and improve equity.

Additionally, institutional weaknesses and inadequate monitoring frameworks continue to impede delivery. Programs often lack robust accountability mechanisms, resulting in misallocation and low responsiveness to agroecological and social diversity. The findings emphasize the need for integrated reform—combining policy, institutional, and technological innovation—to transform subsidies into catalysts for inclusive and climate-resilient agricultural transformation.

10.2 Contributions to Agricultural Policy Reform

This paper contributes to the discourse on agricultural policy reform by articulating a comprehensive and evidence-informed assessment of how subsidies can be better structured and delivered. It emphasizes that subsidies should not be treated as standalone interventions but must be embedded within holistic agricultural development strategies that address market failures, climate resilience, and social inclusion simultaneously.

By outlining comparative insights from countries such as Kenya, Rwanda, Malawi, Nigeria, and Zambia, the study identifies best practices and pitfalls that policymakers can use to recalibrate existing models. It advocates for performance-based, pro-poor designs supported by strong governance systems, transparent monitoring tools, and community-driven oversight. Moreover, it stresses the strategic value of digital transformation as a vehicle for both efficiency and accountability.

In doing so, the paper provides a practical framework for governments, development partners, and practitioners seeking to redesign subsidy systems in ways that align with sustainable development goals and long-term rural prosperity.

10.3 Areas for Further Study

While this paper has covered a broad scope, several areas merit deeper investigation to inform future subsidy reforms. First, there is a need for longitudinal impact evaluations that assess not only short-term adoption outcomes but also medium- to long-term changes in household welfare, farm resilience, and market participation. Most current evaluations are short-term and do not capture post-subsidy transitions or behavioral shifts.

Second, further study is required on the gendered impacts of subsidy access, particularly how digital innovations affect women's participation in agriculture. Research should explore the barriers and enabling conditions for making digital subsidy systems truly inclusive and equitable.

Third, there is scope to examine the environmental impacts of subsidized input use, including soil health, biodiversity, and carbon emissions. Understanding these ecological footprints will be critical for designing subsidies that align with green growth and climate adaptation strategies. Multi-disciplinary research combining agronomy, economics, and environmental science will be essential in this endeavor.

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