

Economic Analysis of Fuel Subsidy Removal on Smallholder Sorghum Farmers' Production Cost in Zuru Agricultural Zone, Kebbi State, Nigeria

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Abstract: When Nigeria ended its petrol subsidy in May 2023, fuel and transport prices climbed steeply, prompting fears that the cost of farming would rise for small-scale producers. This paper investigates how the policy change influenced the cost of producing sorghum in Zuru Agricultural Zone, Kebbi State, which farmer characteristics explained differences in the cost increase, and what coping measures farmers adopted. A multi-stage sampling design was used to select 240 sorghum farmers from eight markets in the Zuru and Danko/Wasagu Local Government Areas, of whom 239 returned usable questionnaires. The data were examined using descriptive statistics, multiple and binary logit regression, mean effectiveness scores and one-sample t-tests. Most respondents were men (93.7%), most were highly experienced (57.7% had farmed for over 15 years) and operated on a small scale, and only a few had reached extension services (11.7%), credit (7.1%) or cooperatives (8.4%). Production cost was positively and significantly related to fuel price ($\beta = 0.472$), transportation cost (0.361), labour cost (0.287) and fertilizer cost (0.214), with $R^2 = 0.801$, and 70.7% of respondents reported that their costs had been affected ($t = 7.021$, $p < 0.05$). Farmers with more education, longer experience and bigger farms experienced smaller percentage increases in cost, while contact with extension agents reduced the probability of being affected. Farmers coped mainly by using local inputs (89.5%) and fuel-efficient machinery (89.1%), but rated these responses as only moderately effective (mean score = 2.43). The findings indicate that subsidy removal raised sorghum production cost significantly. Targeted input support, better rural roads, and stronger extension, credit and cooperative services are recommended.

Keywords: fuel subsidy removal, sorghum production cost, adaptation strategies, smallholder farmers, Kebbi State

Introduction: Agriculture is central to the Nigerian economy, accounting for a large share of Gross Domestic Product and providing work for much of the labour force. Sorghum (*Sorghum bicolor*) holds a strategic place among the country's cereals: it feeds millions of households, earns cash for smallholders, and supplies the brewing, livestock feed and food-processing industries (IITA, 2020). Because the crop withstands drought and poor soils and needs relatively few inputs, it is especially valuable for food security in the semi-arid and savannah belts of northern Nigeria, Kebbi State included (Jirgi *et al.*, 2018). Sorghum is grown largely by smallholders who rely on purchased inputs, hired labour and road transport, both to carry inputs to the farm and to take produce to market. Higher fuel prices therefore pass quickly into their costs. Successive Nigerian governments long held petroleum prices below import cost through subsidies (Bakare, 2012). The Federal Government announced the end of the petrol subsidy on 29 May 2023, and pump prices then rose sharply and more than once over the following months. Fuel enters farming directly through land preparation, irrigation, milling and haulage, and indirectly through the transport of fertilizer, agrochemicals, seed and labour to the farm (World Bank, 2022; Adediran *et al.*, 2023). Fertilizer and agrochemical prices are also

affected, since both are distributed over long distances by road (IFPRI, 2022). Cost-push theory explains why such an effect is expected. If the price of an important input like fuel goes up, so does the cost of production, and producers must either accept thinner margins or raise the prices they charge (Dunn, 2015). Smallholders are particularly vulnerable because few have the credit, extension advice or cooperative support needed to buffer such shocks (African Development Bank, 2021). Research on subsidy removal in Nigeria has mostly concentrated on macroeconomic outcomes, including inflation, urban transport and food security, while farm-level studies have covered Niger, Benue, Oyo, Gombe and parts of the North-West. To the authors' knowledge, none has measured the impact on sorghum production cost in Zuru Agricultural Zone, a major sorghum-growing area in north-western Nigeria. This study accordingly aimed to (i) describe the socio-economic and institutional characteristics of sorghum farmers in the zone; (ii) estimate how subsidy removal affected sorghum production cost; (iii) identify the factors behind differences in the cost increase; and (iv) establish which strategies farmers used to limit the impact and how well they worked. Two null hypotheses were tested at the 5% level: H_{01} , that subsidy removal had no significant effect on sorghum production cost; and H_{02} , that farmers'

Economic Analysis of Fuel Subsidy Removal on Smallholder Sorghum Farmers' Production Cost in Zuru Agricultural Zone, Kebbi State, Nigeria

socio-economic and institutional characteristics had no significant influence on the rise in production cost.

Methodology: Study area: The research was carried out in Zuru Agricultural Zone, one of Kebbi State's four emirates, which covers the Danko/Wasagu, Fakai, Sakaba and Zuru Local Government Areas. The zone falls within the Northern Guinea Savannah, receives roughly 950 mm of rain a year and has well-drained sandy loam soils that suit arable farming. Its people are mainly small-scale farmers growing arable crops, with sorghum the most prominent.

Sampling and data collection: The study used multi-stage sampling. First, Zuru and Danko/Wasagu were purposively chosen from the four Local Government Areas because sorghum is chiefly produced there. Second, four villages were selected in each, making eight in total, and third, one major sorghum market was randomly chosen in each village. Fourth, respondents were allocated across the eight markets, with 40 each from the Ribah, Bena, Dabai and Zuru central markets and 20 each from Danko, Maga, Bedi and Alambelu, for a total of 240. Trained enumerators collected primary data with a structured questionnaire in 2025. Of the questionnaires, 239 were returned and usable (a 99.6% response rate), and every analysis rests on these. Participation was voluntary, and verbal consent was obtained from each respondent.

Analytical techniques: Frequencies, percentages and means described the farmers' characteristics and their adaptation strategies. To estimate the effect of subsidy removal on production cost, a multiple regression cost function was fitted in four functional forms (linear, semi-log, double-log and exponential), and the lead equation was chosen using R^2 , adjusted R^2 , the F-ratio, the number of significant coefficients and conformity with expected signs (Gujarati and Porter, 2009; Greene, 2018). The double-log form is written as

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + e$$

where Y is total sorghum production cost per season (₦); X_1 is the rise in the petrol pump price (₦/litre); X_2 is the cost of transporting farm inputs; X_3 is labour cost; X_4 is fertilizer cost; X_5 is agrochemical cost (all in ₦); and X_6 is farm size (hectares). The coefficients can be read as elasticities. Factors behind the rise in cost were examined with two models: a multiple regression of the percentage increase in production cost, and a binary logit model (McFadden, 1974) of whether a farmer's cost was affected (1 = yes, 0 = no). Both used age, education, household size, farming experience and farm size, together with dummy variables for extension contact, credit access and cooperative membership. Adaptation strategies were handled as multiple responses and ranked, and perceived effectiveness was scored on a four-point scale (very effective = 4 to not effective = 1) with a decision point of 2.50. H_{01} was tested with a one-sample t-test against a test value of 0.50 and

through the significance of the fuel price coefficient. H_{02} was tested through the overall significance of the two models (F-ratio and likelihood ratio chi-square) and the significance of individual coefficients.

Results and Discussion: Socio-economic and institutional characteristics: Table 1 presents the respondents' main characteristics. Sorghum farming in the zone is predominantly done by men (93.7%), and two-thirds of farmers (66.5%) were between 31 and 50 years old. Education levels varied, with 41.4% having no formal schooling and 34.7% having tertiary education. Farmers were highly experienced (57.7% had farmed for more than 15 years) and operated on a small scale (53.1% cultivated three hectares or less). Institutional support was very limited: just 11.7% had contact with extension services, 7.1% had credit and 8.4% belonged to a cooperative or association. This is consistent with reports that scarce rural credit is a major constraint on Nigerian agriculture, and it implies that most farmers confronted the cost increase without the information, finance or group support that might have softened it.

Effect of fuel subsidy removal on sorghum production cost: The double-log form was selected as the lead equation because it recorded the highest R^2 (0.801), adjusted R^2 (0.792) and F-ratio (52.47, significant at 1%), and had the most significant coefficients, all with the expected signs (Table 2). The six explanatory variables thus account for about 80.1% of the variation in production cost. Since the coefficients are elasticities, each 1% increase in the pump price of fuel corresponds to a 0.47% increase in sorghum production cost, the largest effect of any variable. The rise in fuel price after subsidy removal was therefore carried straight through to farm costs, which matches World Bank (2024) reports of immediate increases in transport, input distribution and mechanisation costs. Transportation cost (0.361) was also significant at 1%, in agreement with Okeke and Nwosu (2022), who identified transport as a major driver of farm expenses in rural Nigeria. Labour cost (0.287) and fertilizer cost (0.214) were significant at 5%, reflecting higher wages and the passing on of haulage charges in fertilizer prices. Larger farms had higher total costs because they use more inputs and labour. The agrochemical coefficient was positive but insignificant, probably because agrochemicals form a smaller part of total cost than transport, labour or fertilizer.

For H_{01} , the mean response of 0.707 (standard deviation 0.456) indicates that 70.7% of farmers said subsidy removal had affected their production cost, a share significantly above the neutral value of 0.50 ($t = 7.021$, $p < 0.05$). With the significant fuel price coefficient ($t = 3.91$), this led to rejection of the null hypothesis: subsidy removal significantly raised sorghum production cost in the study area.

Factors influencing the increase in production cost: Table 3 reports both models. In the regression on the percentage rise in production cost ($R^2 = 0.742$; $F = 12.846$, p

Economic Analysis of Fuel Subsidy Removal on Smallholder Sorghum Farmers' Production Cost in Zuru Agricultural Zone, Kebbi State, Nigeria

< 0.01), education, farming experience and farm size had significant negative coefficients at the 5% level, meaning that better-educated, more experienced and larger-scale farmers experienced smaller percentage increases. Educated and experienced farmers can more readily find cheaper inputs and adjust to price changes (Schultz, 1964), and larger farms can spread higher fuel and transport costs across more land. Extension contact and credit access, by contrast, had significant positive coefficients, which runs against expectation. One plausible reason is that such farmers are more market-oriented and rely more on purchased inputs. The result should nonetheless be treated cautiously, as only 28 farmers had extension access and 17 had credit, and it indicates association rather than causation. In the logit model (LR $\chi^2 = 102.55$, $p < 0.01$), extension access significantly lowered the probability of being affected (odds ratio = 0.212, equivalent to about 79% lower odds), underlining the part extension plays in supplying information on cost-saving practices and input sources. Farmers with larger farms (odds ratio = 1.463) and those using credit (3.065) were more likely to report an effect, reflecting their greater reliance on purchased inputs and transport (Barrett, 2008; Khandker, 2005). Education also increased the odds of reporting an effect, which seems to contradict the regression result but does not, because the two models capture different things: the logit shows whether a farmer reports being affected, while the regression shows how large the increase was among farmers. Cooperative membership was significant only at 10%, and age and household size were insignificant in both models. As both models were significant overall and several coefficients were significant at 5% or better, H_0 was rejected.

Adaptation strategies and their effectiveness: Farmers could use more than one strategy (Table 4). The commonest were using local inputs (89.5%) and fuel-efficient machines (89.1%), followed by reducing the use of fuel-based machinery and replacing hired transport with local means (88.3% each). These choices indicate a shift toward low-energy farming, consistent with evidence that smallholders adopt energy-saving practices when fuel prices go up (IFAD, 2023). Other strategies, including family labour, lower fertilizer and agrochemical quantities and adjusted planting time, save cash in the short run but may lower yields or efficiency (Von Braun, 2023). On effectiveness, 52.7% of farmers judged the strategies very effective (7.5%) or effective (45.2%), 29.7% judged them moderately effective and 17.6% not effective. The mean score of 2.43 falls short of the 2.50 decision point, so the strategies were only moderately effective: they ease the pressure without removing it. This is unsurprising, because most are individual, short-term responses adopted with little extension, credit or cooperative backing.

Conclusion and Recommendations: The study concludes that removing the fuel subsidy significantly raised the cost of producing sorghum in Zuru Agricultural Zone. The rise worked mainly through higher fuel prices and higher transportation, labour and fertilizer costs, with fuel price itself having the strongest effect. The impact was uneven:

education, experience and farm size were linked to smaller percentage increases and extension contact lowered the probability of being affected, yet most farmers have no extension, credit or cooperative support. Farmers' own responses were largely individual and short-term, were rated only moderately effective, and may in some cases reduce yields. Without support, higher production cost could erode the profitability of sorghum farming and endanger the crop's supply. The study therefore recommends that: Federal and State Governments offer targeted, voucher-based support for fertilizer and improved seed to smallholder sorghum farmers; governments at all levels rehabilitate feeder roads and encourage agro-dealers to set up closer to farming communities in order to cut transport cost; extension services, such as the Kebbi State Agricultural Development Project, receive better funding so they can reach more farmers with advice on saving costs; affordable, input-linked credit, accompanied by guidance on input management, be made available to sorghum farmers; farmer cooperatives be supported to purchase inputs in bulk and to share transport and machinery; and fuel-saving technologies and locally available organic inputs be promoted, while farmers are cautioned against cutting fertilizer to levels that depress yields.

The study's limitations include dependence on farmers' recall of conditions before subsidy removal and a sample that is overwhelmingly male. Further research could use farm records or panel data, cover other crops and zones, and examine effects on yield, income and food security.

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Table 1: Selected Socio-economic and Institutional Characteristics of Respondents (n = 239)

Variable / category	Frequency	Percentage
Male	224	93.7
Age 31–50 years	159	66.5
No formal education	99	41.4
Tertiary education	83	34.7
More than 15 years of farming experience	138	57.7
Farm size of 3 hectares or less	127	53.1
Farming as primary occupation	186	77.8
Access to extension services	28	11.7
Access to credit	17	7.1
Member of cooperative/association	20	8.4

Source: Field Survey, 2025.

Table 2: Double-log Regression Estimates of Sorghum Production Cost (n = 239)

Variable	Coefficient	t-value	Significance
Constant	1.765	2.86	1%
Fuel price increase (X ₁)	0.472	3.91	1%
Transportation cost (X ₂)	0.361	3.24	1%

Economic Analysis of Fuel Subsidy Removal on Smallholder Sorghum Farmers' Production Cost in Zuru Agricultural Zone, Kebbi State, Nigeria

Variable	Coefficient	t-value	Significance
Labour cost (X_3)	0.287	2.75	5%
Fertilizer cost (X_4)	0.214	2.27	5%
Agrochemical cost (X_5)	0.109	1.21	Not significant
Farm size (X_6)	0.246	2.36	5%
R^2 / Adjusted R^2	0.801 / 0.792		
F-ratio	52.47		1%

Source: Field Survey, 2025.

Table 3: Factors Influencing Production Cost Increase (Regression) and the Likelihood of being Affected (Logit)

Variable	Regression coefficient	p-value	Logit odds ratio	p-value
Age	-1.069	0.837	1.164	0.400
Education	-8.440**	0.021	1.568**	0.032
Household size	-4.503	0.404	0.930	0.690
Farming experience	-9.797**	0.036	1.000	0.999
Farm size	-11.584**	0.030	1.463**	0.041
Extension	34.429**	0.035	0.212***	0.004
Credit	38.837**	0.041	3.065**	0.018
Cooperative	23.352	0.179	4.153*	0.085
R^2 / Pseudo R^2	0.742		0.68	
F-statistic / LR χ^2 (8 df)	12.846***		102.55***	

Source: Field Survey, 2025. ** significant at 1%, at 5%, at 10%.

Table 4: Adaptation Strategies Adopted by Farmers (n = 239, multiple responses)

Adaptation strategy	Frequency	Percentage	Rank
Used local inputs instead of purchased inputs	214	89.5	1st
Used fuel-efficient machines	213	89.1	2nd
Reduced the use of fuel-based machinery	211	88.3	3rd
Replaced hired transport with local means	211	88.3	3rd
Used family labour instead of hired labour	208	87.0	5th
Practised mixed cropping	203	84.9	6th

Economic Analysis of Fuel Subsidy Removal on Smallholder Sorghum Farmers' Production Cost in Zuru Agricultural Zone, Kebbi State, Nigeria

Adaptation strategy	Frequency	Percentage	Rank
Reduced fertilizer and agrochemical quantities	202	84.5	7th
Adjusted planting time	200	83.7	8th

Source: Field Survey, 2025.