Research Journal of Agricultural Economics and Development
ISSN 2997-5980 • Volume 5, Issue 1, 2026 • pp. 120–131

RESEARCH ARTICLE

Received: 13 Aug 2026, Accepted: 25 Aug 2026, Published: 11 Sep 2026

Analysis of Spatial Patterns of the Fertilizer Value Chain Actors and their Market Determinants in Kaduna State, Nigeria

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Abstract

The study examined the spatial patterns of fertilizer value chain actors. A multistage sampling technique was used. Five LGAs were randomly selected using the card system technique, Ten Fertilizer companies, 41 Agro-dealers, 15 transporters, 484 farmers, and 220 retailers. A zero-inflated model was used to account for the prevalence of zero values; spatial autocorrelation integrated a neighbouring structure approach and clustered distribution patterns are prominent across the board (z=-21.94, p<.01). The z-scores revealed the likelihood of the cluster occurring randomly is less than 1%. The examination underscored clustering as an area-based and commodity-based phenomenon. Evaluation of the model was anchored in an alpha level of 0.05. The model's overall significance emerged with a notable outcome, $x^2\ (7) = 49.91$, p<.001, underscoring the substantive influence of age, education, household size, farm size, cooperative association, credit, and distance on the spatial patterns. McFadden R-squared for this particular model stood at an impressive 0.8.

Keywords: Agro-dealers, Blenders, Fertilizer value chain, Spatial pattern.

How to Cite: Maina, M., Oladimeji, Y. U., Sanni, A., & Hussaini, A. S. (2026). Analysis of Spatial Patterns of the Fertilizer Value Chain Actors and their Market Determinants in Kaduna State, Nigeria. Research Journal of Agricultural Economics and Development, 5(1), 120–131. https://doi.org/10.52589/RJAED-PDCCTCPS

INTRODUCTION

The Spatial distribution of fertilizer value chain actors along different geographies may be due to certain factors that attract the actors to be situated in such places. In Nigeria, the actors namely producers, blenders, importers, and agro-dealers are spread across the country depending where their market is located, proximity to port, farmers, or storage facilities. According to Alliance for Green Revolution in Africa (AGRA) (2018), the spatial distribution of fertilizer actors in Nigeria is heavily concentrated around northern agro-ecological zones and major urban corridors. Manufacturers and blending plants primarily cluster in the North-West and North-Central, while southern regions rely on lengthy transport supply chains driven by wholesale traders. AGRA (2018) also noted that large-scale entities like Indorama (Eleme), Office Chérifien des Phosphates (OCP) Africa, and Notore are situated near coastal import hubs (like Port Harcourt) or major domestic resource zones. Blending plants, however, cluster heavily in northern states (e.g., Kaduna and Kano) closer to major agricultural demand centers (AGRA, 2018). The spatial patterns have defined by different scholars from different point of views. One view considers their essence as the concentration of various entities in the agricultural industry chain (including production, processing, and marketing) in a specific geographical area (Wardhana et al., 2017), while the other describes them as the aggregation of related economic activities centred on agriculture and capable of generating income and employment in a specific region (Dureti et al., 2023).

According to FAO (2020), between 2015–2019, Africa represented over 3.5% of the global agricultural use for nitrogen and phosphorus-based fertilizers, and a little above 2 percent for potassium-based fertilizer. The report also added that the share for SSA is generally less than 1%. In 2002, the average intensity of fertilizer use in Sub-Saharan Africa was only 8 kg/ha of cultivated arable land, and this was far lower than what was obtainable in other developing regions of the World. These high levels of concentration results largely from the fact that fertilizer production relies on raw materials that are not available worldwide. In addition, fertilizer production requires large upfront investment with sizable economies of scale. Yet high concentration levels can also generate market power exertion and tacit collusion among the few operating firms (Hernandez et al., 2018). The spread of these blending plants is mostly in a particular region of the country because the Northern soils require more fertilizers and that is where most of the grain production takes place, this is by far the more reason why most of the fertilizer blending companies are located and to benefit from proximity to the farmers they serve.

According to Potter et al., (2009), global demand and supply chain actors often cluster near high-yield agricultural zones. In countries like India, for example, geospatial mapping shows massive regional imbalances, with excessive fertilizer applied in the Indo-Gangetic plains while other areas remain nutrient-deficient. Spatial patterns in fertiliser use arise from agro-ecological continuity, irrigation access, cropping systems and market linkages that often extend across district boundaries (Qu et al., 2025). On the global scale, given the volumes exported via the Strait of Hormuz, nitrogen and phosphates are the most affected product families. Potash is not directly affected but could be impacted by worsening cross-nutrient affordability. Raw material exposure is also important to consider, phosphate capability is forecast to be impacted by up to 3 Mt per year, but affordability impacts could be broader given the contribution of the region to global trade of ammonia and sulphur which are imported as raw materials for phosphate production elsewhere (International Fertilizer Association, IFA, 2026).

ISSN 2997-5980 • Volume 5, Issue 1, 2026 • pp. 120–131

In Nigeria, the story is not different because the country imports raw materials from other countries with the exception of Urea. The major raw materials imported are: Diammonium phosphate (DAP), Muriate of Potash (MOP) and Granular Ammonium Sulphate (GAS) which are imported from different countries to serve the local blending plants. The object of this study is to show the spatial distribution and clustering of actors as part of that is based on geography and commodity. Hence, we investigated spatial distribution of actors in the fertilizer value chain. This was approached by collecting the required data from the various value chain actors using a structured questionnaire and administered by trained enumerators. Outside the visualization, the study also considers how different actor groups relate to each other in spatial terms in order to ascertain their locations and why actors move to certain areas, and why some are clustered together in some areas. The spatial distribution pattern revealed clustering which was based on two items; geography and commodity. However, there is the dirt of empirical literatures that addressed the spatial distribution pattern of fertilizer companies and other actors in Nigeria and based on that, the study addressed some of the reason for the spatial patterns and the factors that determines their spread and location. The study looked at the clustering phenomenon that was addressed both in terms of geography and commodity using the spatial factor model.

The spatial factor analysis is a combination of traditional multivariate factor analysis with spatial statistics that help to model and reduce dimensionality in a geographically referenced data while at the same time accounting for autocorrelations. Palmas and Chamberlin (2020) used the spatial model to analyse spatial distribution of soil and rainfall, farmers and farmlands, and input and output prices. The aspect of spatial proximity is crucial for fulfilling the multifunctional role of organic farming and should therefore be central to the assessments, in science as in policy. Studies reveal that several factors account for the uneven distribution of organic agriculture, including physical, structural, socio-cultural, and economic factors (Kujala et al., 2022).

MATERIALS AND METHODS

The study area is Kaduna State, Nigeria, and the State lies between Latitude 09º 02' and 11º32' North and Longitude 96º 15' and 08º 60' East of the Greenwich meridian. The state has a landmass of about 46,016 Km² which is equivalent to about 5% of the Nigeria's land mass of 923,768 square kilometers, it is located in the central region of Nigeria. Kaduna State is made up of 23 Local Government Areas (LGAs) and a population of 6,133,503 people based on 2006 census (NPC, 2009). The projected population of the state at 3.2%t growth rate is put at 9,837,937 people as at 2021 projections. The soil type in the state consists of red-brown to red-yellow ferruginous tropical soils which are heavily weathered and markedly laterized. They are mostly formed on granite and gneiss parent materials, and on aeolian and many sedimentary deposits. The whole state is covered by the tropical grassland vegetation with the density of trees and other plants decreasing as one move northwards (Abaje, 2007). According to Kaduna State Agricultural Survey (2017), 97.3% of the farmers in the state use fertilizer for farming which are mostly inorganic/mineral fertilizer but 43.1% use both organic and inorganic.

Spatial Factor Model

Spatial analysis was used to explain variation among the farmers in their selection of a specific fertilizer market outlet. This study assumes that farmer's decision is generated based on utility maximization.

ISSN 2997-5980 • Volume 5, Issue 1, 2026 • pp. 120–131

$$Y_{i1} = (V_1 + \lambda_{11}\eta_{i1} + \lambda_{12}\eta_{i2} + \lambda_{1k}\eta_{ik})\ \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + (V_1 + \lambda_{11}\eta_{i1} + \lambda_{12}\eta_{i2})\ + e_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where:

Y_i = market outlets (wholesalers, agro-dealers, retailers),

V_1= Constant,

$\lambda_i - \lambda_k$ = slope or coefficient,

η_i - η_k = explanatory variable (qualitative),

β_1 - β_4 = slope or coefficient (quantitative),

$Z_1 - Z_4$ = explanatory variable (quantitative),

η_{i1}= educational status (literate=1, not literate=0),

η_{i2}= membership in farmers' cooperative (member=1. Non-members=0),

η_{i3}= mode of payment (Cash=1, credit=0),

Z_1= amount of credit obtained (₦),

Z_2= distance to farmers center (km),

Z_3= quantity of fertilizer supply (kg),

Z_4= price of fertilizer (₦);

η_{i1}= location of delivery (Marketer's place =0, Farmer's community =1, collection point=2),

η_{i2}= price setting (market price=0, market price + 10% =1, market price + 20%=2), α_0= a vector of parameters to be estimated and

e_i= disturbance term

The research was directed towards gauging the determinants and spatial distributions of different participants within the fertilizer value chain. A comprehensive approach was employed, utilizing both a determinant and spatial factor model, followed by a multinomial logit regression analysis. The sequence involved investigating spatial patterns initially, followed by an exploration of the underlying determinants that contribute to these patterns.

RESULT AND DISCUSSIONS

Spatial Patterns of Various Actors in the Fertilizer Value Chain

The sparse utilization of fertilizer in Nigeria, particularly within Kaduna state, has necessitated the application of specialized models to unravel underlying dynamics. In this context, this study employed zero-inflated models to account for the prevalence of zero values and the resultant over-dispersion in the distribution. Expanding upon the model's parameters, the structured additive regression framework enables the examination of diverse variable types within a unified framework. Moreover, the analysis of spatial autocorrelation integrates a neighbouring structure approach, assessing the extent of interrelation among neighbouring local government areas, thereby deviating from treating blending/plant locations as independent entities.

Upon scrutinizing the nearest neighbour summary values (Table 1), it became evident that clustered distribution patterns are prominent across the board (z=-21.94, p<.01). The clustering was observable in specific local government areas, including Lere (z=-20.32, p<.01), Sabon Gari (z=-7.10, p<.01), Kaduna north (z=-4.65, p<.01), and Soba (z=-5.89, p<.01). The z-scores revealed that the likelihood of cluster occurring randomly is less than 1%.

Table 1: Average Nearest Neighbour Summary

Statistic	Lere	Sabon Gari	Kaduna North	Soba	All
Observed Mean (OMD)	0.28	3.24	1.4	0.35	1.46
Expected Mean (EMD)	4.74	5.35	3.21	2.89	6.61
Nearest neighbor Ratio (NNR)	0.06	0.6	0.04	0.12	0.22
z-score	-20.32	-7.1	-4.65	-5.89	-21.94
p-value	0.00	0.00	0.00	0.00	0.00

Source: SPSS Output, 2023

This clustering phenomenon was multifaceted, both in terms of geography and commodity. Geographically, farmers congregated based on the proximity of blending plants/agro-dealers. In terms of commodities, farmers engaged in purchasing similar fertilizers amalgamate their efforts to attain higher volumes and favourable pricing. Clustering within the fertilizer value chain actors served not only as a production and marketing strategy but also facilitates collective marketing among smallholder farmers, a concept highlighted in previous studies (Uy, 2005; Mendoza, 2006). Such clustering strategies were recognized for stimulating innovation, competitiveness, and interaction, as observed in Kenya (Bolo, 2006).

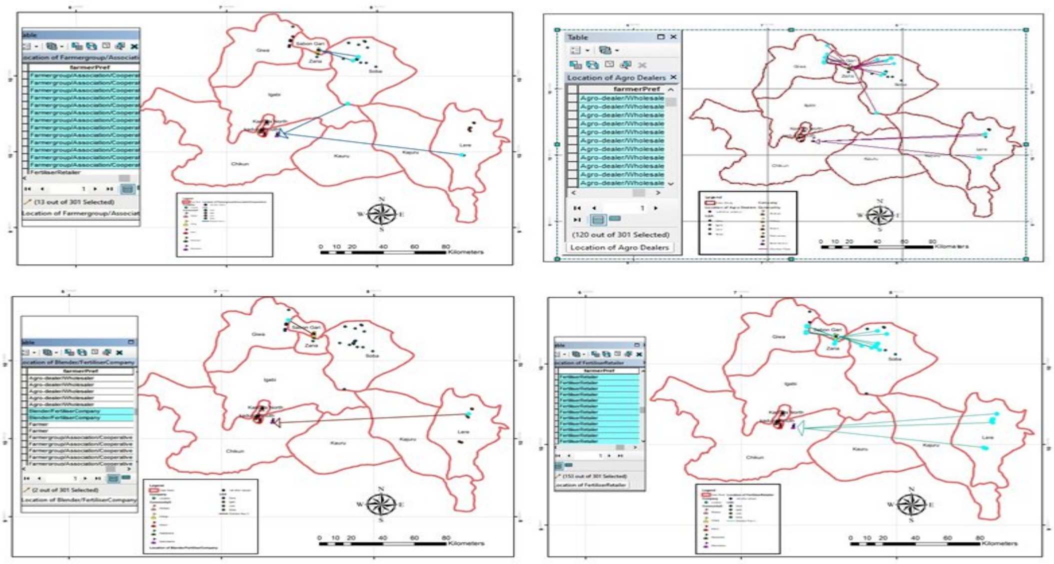

Figure 1: Spatial Patterns of Various Actors in the Fertilizer Value Chain

Spatial visualization, depicted in Figure 1, unveils the distribution patterns of fertilizer value chain actors across Kaduna State. This map showcased distinct local government areas – Lere, Sabon Gari, Kaduna north, and Soba – each identified and labelled. Further granularity was provided in respective spatial patterns maps for each of these areas. This examination underscores clustering as an area-based and commodity-based phenomenon, revealing the coming together of neighbouring farms for cooperative purchasing to enhance volumes. However, these findings also spotlight challenges such as economies of scale and competition that accompany clustering efforts. Consequently, while these clusters primarily focused on meeting consumer/farmers' demands, they may not necessarily lead to increased efficiency and productivity. This aligns with previous research emphasizing the consumer-driven orientation of fertilizer clusters (Galvez-Nogales, 2010; Montiflor *et al*., 2008).

This research not only underscored the significance of clustering but also highlights the need for comprehensive strategies that account for spatial dynamics, varying regional conditions, and consumer-centric perspectives. The broader implications extend to policy making, extension service planning, and overall enhancement of the fertilizer value chain's efficiency and effectiveness. The findings corroborate existing literature on clustering as a strategy for collective purchasing and marketing among farmers (Uy, 2005; Mendoza, 2006; Bolo, 2006). The study's spatial analysis reinforced the importance of this approach in stimulating interaction, innovation, and long-term competitiveness, as noted in previous research (Galvez-Nogales, 2010; Montiflor *et al*., 2008).

Factors that Determine the Spatial Patterns

To comprehend the potential influence of various factors on the spatial patterns exhibited by actors within the fertilizer value chain (FVC), a binary logistic regression analysis was executed. The exploration encompassed age, education, household size, farm size, cooperative association credit, and distance as potential predictors. Importantly, the assumption of the absence of multicollinearity was meticulously assessed.

In order to detect the presence of multicollinearity, Variance Inflation Factors (VIFs) were computed. Elevated VIFs indicate an escalating impact of multicollinearity within the model. Concern arises when VIFs exceed 5, with a maximum upper limit of 10 to be regarded with caution (Menard, 2009). Encouragingly, all predictors featured VIFs below 10, signifying a satisfactory absence of severe multicollinearity. The specifics of VIF values for each predictor are meticulously detailed in Table 2.

Evaluation of the model was anchored in an alpha level of 0.05. The model's overall significance emerged with a notable outcome, $\chi2(7) = 49.91$, $p<.001$, underscoring the substantive influence of age, education, household size, farm size, cooperative association, credit, and distance on the spatial patterns witnessed in the FVC. To gauge the model's fit, McFadden's R-squared was computed. A value exceeding 0.2 is indicative of a model with exceptional fit (Louviere *et al*., 2000). Evidently, the calculated McFadden R-squared for this particular model stood at an impressive 0.8. These outcomes align with prior research emphasizing the multifaceted nature of spatial patterns within agricultural value chains. Age, education, household size, farm extent, cooperative involvement, credit access, and geographical proximity have been widely recognized as factors intertwining with spatial patterns in various agri-related activities (Lauwers & Vandevelde, 2014; Baudron *et al*., 2017).

The absence of severe multicollinearity within the model enhances the reliability of these findings. This suggests that the identified predictors independently contributed to shaping

ISSN 2997-5980 • Volume 5, Issue 1, 2026 • pp. 120–131

spatial patterns, substantiating the intricate interplay between socio-demographic variables and the dynamics of fertilizer distribution. The noteworthy model fit (McFadden R-squared = 0.8) underscored the robustness of the selected predictors in explaining spatial patterns. Such a high fit coefficient implied that a substantial portion of the variability in the spatial patterns can be elucidated by the combined influence of age, education, household and farm size, cooperative association, credit, and distance.

Table 2: Factors that determine the spatial patterns

Variable	B	SE	$\chi2$	p-value	OR	VIF
Intercept	2.42	0.45	29.15	0.001	-	
Age	-0.04^{***}	0.01	13.2	0.001	0.96	1.78
Education	0.02	0.09	0.04	0.839	1.02	1.04
Mode of payment	0.006	0.02	0.08	0.783	1.01	1.81
Quantity supply	-0.02	0.02	0.45	0.503	0.98	1.32
Price of fertilizer	0.01	0.078	0.35	0.659	1.21	1.41
Location of delivery	0.021	0.03	0.09	0.783	1.01	1.81
Price setting	-0.44	0.162	0.76	0.503	0.78	1.71
Cooperative	-0.46^{**}	0.21	4.74	0.029	0.63	1.08
Credit	1E-06	9E-07	1.51	0.218	1.00	1.2
Distance to farmers center	-0.04^{***}	0.02	7.11	0.008	0.96	1.07
Note. $\chi2(7) = 49.91$, $p < .001$, McFadden $R^2 = 0.8$.						

The influence of age emerged as statistically significant (B = -0.04, OR = 0.96, $p < .001$), highlighting that a one-unit increment in age leads to an approximate 96% reduction in the spatial patterns exhibited by actors within the FVC. Surprisingly, the age of respondents displayed an unexpected negative relationship with the selection of alternative market locations. Contrary to initial expectations, older farmers exhibited a preference for specific locations where they could procure fertilizer. A rise in age by a single year corresponded to a substantial 96 per cent decline in the likelihood of not choosing an alternative market location.

It's intriguing to observe that younger farmers displayed a more robust network of connections with diverse market outlets compared to their older counterparts. This enhanced connectivity could be attributed to their access to marketing information and proficiency in utilizing contemporary media technologies. This phenomenon diverged from the findings of Adegbola & Gardebroek (2007), who noted that older farmers in Benin exhibited a preference for rural assemblers over wholesalers due to established long-term relationships. Similarly, in Louisiana, USA, Nyaupane *et al.* (2010), reported that older farmers leveraged their accumulated market knowledge to positively impact their choice of marketing channels.

The unanticipated negative correlation between age and the selection of alternative market locations underscores the complexity of age-related dynamics within the context of fertilizer distribution. While this finding contrasts with certain previous studies, it corroborates the notion that age-related factors can exert varying impacts on marketing channel preferences, influenced by cultural, technological, and regional nuances. The augmented connectivity of younger farmers through modern media technology aligns with the contemporary trend of technology shaping marketing practices and networking behaviours in agriculture (Sarker *et al*., 2020). This affirms the evolving role of digital tools in shaping market engagement strategies, indicating a broader paradigm shift in information dissemination and networking practices.

Cooperative membership exhibited a noteworthy negative association, indicating a diminished likelihood of respondents selecting alternative markets. This influence on market choice was found to be statistically significant at the 5 per cent level. Interestingly, this finding diverges from the observations of Odebiyi (2010), who highlighted that cooperative groups tend to facilitate benefits for their members, which might not be attainable individually. The counterintuitive negative correlation between cooperative membership and choosing alternative markets adds a layer of complexity to the dynamics of cooperative influence. While Odebiyi (2010) emphasized the benefits that cooperative membership can confer, this study suggests that cooperative membership could potentially lead to a more conservative approach in market selection. This contrast underscores the intricate interplay between cooperative membership, market preferences, and individual decision-making.

These results underscore the need for a deeper exploration of the specific mechanisms through which cooperative membership impacts market choices. This finding could potentially prompt a re-evaluation of how cooperatives communicate and encourage members to explore alternative market avenues. Tailoring cooperative initiatives to align with members' evolving preferences and providing education on the benefits of diversification may enhance the effectiveness of cooperative influence on market choices. Moreover, understanding the nuanced relationship between cooperative membership and market preferences could inform strategies to optimize the cooperative's role in facilitating improved access to markets, resources, and value-added opportunities for its members. The presence of credit access emerged as a determining factor in respondents' likelihood to opt for an alternative market location. Confirming expectations, the positive and statistically significant relationship of credit access at the 5 per cent level indicates that respondents who enjoy credit access are more inclined to choose alternative market locations compared to those without such access. Remarkably, the calculated marginal effect of 1.0 underscores that an additional credit opportunity heightens the probability of respondents selecting an alternative market location by an impressive 100 per cent.

This observation aligns with the notion that credit access bolsters respondents' capacity to explore diverse market avenues, thereby potentially diversifying their market engagement and enhancing their overall business prospects. The involvement of cooperatives plays a pivotal role in enhancing members' market awareness and fostering stronger intra-member relationships. The positive influence of credit access on opting for alternative markets resonates with the findings of Asfaw *et al*. (2015) and Ahmed (2012), both of whom reported a correlation between credit access and a proclivity for diversifying income sources. This consistency underscores the pivotal role that credit facilities can play in promoting entrepreneurial expansion and facilitating access to varied market opportunities.

These outcomes underscore the significance of credit access as a catalyst for fostering business expansion and market diversification. Policymakers, financial institutions, and cooperatives could leverage these findings to design targeted programs that provide accessible and flexible credit options to agricultural stakeholders. Furthermore, cooperatives' role in bolstering members' market understanding and inter-member relationships signifies their potential as pivotal facilitators in promoting credit utilization for enhanced market engagement. Enhancing credit access and cooperative involvement can serve as complementary strategies to empower agricultural stakeholders to explore alternative markets, reduce dependency on single market outlets, and potentially mitigate risks associated with market volatility.

The distance to an upgraded outlet market emerges as a pivotal determinant, as farmers' interaction with the output market significantly influences information availability. This relationship demonstrates statistical significance at the 1 per cent level, underlining its critical role. The observed negative relationship implies that a unit increment in distance to an alternative market location corresponds to a reduction in the probability of opting for such a decision. Paradoxically, extensive distances to markets can pose a counterproductive impact on farmers' commercialization intentions. This agreed with Amanze & Eze (2010) who confirmed that distance to input market is one of the major limiting factors for inputs purchase as it imposes a high transaction cost to producers. The adoption and fertilizer use intensity decreases with an increase in the distance to the nearest input market. Olayide, Alene and Ikpi (2009) also conducted a study on the determinants of fertilizer use in northern Nigeria, the variables measured include: distance of village to tarred road (km), age of farmer, years of formal education, household size, and total land area cropped among others. The results show that the intensity of fertilizer use increases with family labour and physical access to fertilizer, but declines with cultivated land and plot distance from homestead.

Interestingly, the market with improved access is situated farthest from respondents' residences compared to other output markets. These results spotlight the pivotal role of geographic accessibility in shaping farmers' market decisions. Agribusinesses, and extension services could leverage these findings to design interventions that enhance market accessibility through improved transportation infrastructure, establishment of satellite markets, or targeted information dissemination systems. By mitigating the impact of distance barriers, these initiatives can foster enhanced market engagement and facilitate better information flow, subsequently promoting agricultural commercialization and livelihood improvement. Furthermore, a deeper exploration of the reasons behind the observed longer distance to the market with improved access could reveal opportunities for optimizing market infrastructure and strategically locating upgraded outlets closer to farmers. This step could effectively reduce the hindrance posed by extensive distances, promoting a more vibrant and efficient agricultural marketing ecosystem. The negative association between distance and market choice aligns with existing literature that underscores the influential role of proximity in shaping farmers' engagement with markets (Nyaupane *et al*., 2010; Baudron *et al*., 2017). The finding corroborates the widely recognized notion that geographical accessibility significantly affects farmers' ability to access markets and transmit vital information. This study is meant to provide valuable information on why actors within the fertilizer value chain cluster based on geography or commodity. This will help policy makers in designing policies that would help the actors in their various clusters. It will also provide real time information on the location of the actors, their spatial distribution so that developmental projects could be directed towards assisting the actors. This will provide them with an opportunity to benefit from proximities to market, inputs and other basic infrastructure.

CONCLUSION

The clustering phenomenon is multifaceted, both in terms of geography and commodity. Geographically, farmers congregated based on the proximity of blending plants or agro-dealers. In terms of commodities, farmers engaged in purchasing similar fertilizers amalgamate their efforts to attain higher volumes and favourable pricing. Clustering within the fertilizer value chain actors served not only as a production and marketing strategy, but also facilitates collective marketing among smallholder farmers. Further granularity is provided in respective spatial patterns maps which underscores clustering as an area-based and commodity-based phenomenon, revealing the coming together of neighbouring farms for cooperative purchasing to enhance volumes. However, these findings also spotlight challenges such as economies of scale and competition that accompany clustering efforts. The influence of age emerged as statistically significant, highlighting that a one-unit increment in age leads to an approximate 96% reduction in the spatial patterns exhibited by actors within the FVC. Cooperative membership exhibited a noteworthy negative association, indicating a diminished likelihood of respondents selecting alternative markets. This influence on market choice was found to be statistically significant at the 5%. These outcomes underscore the significance of credit access as a catalyst for fostering business expansion and market diversification. The distance to an upgraded outlet market emerges as a pivotal determinant, as farmers' interaction with the output market significantly influences information availability. This relationship demonstrates statistical significance at the 1%, underlining its critical role. The observed negative relationship implies that a unit increment in distance to an alternative market location corresponds to a reduction in the probability of opting for such a decision.

RECOMMENDATIONS

The implications of these spatial patterns extend beyond clustering itself, it is therefore recommended that;

1. Extension service providers can leverage this insight to target their education and programming efforts more effectively.

2. Cluster-based approach can mitigate coordination failures in extension programming. The integration of cluster-based strategies into extension service delivery and marketing emphasizes its significance and opens avenues for its inclusion in strategies to enhance efficiency and effectiveness in extension services. Variables such as perceived product quality or distance to service providers, may significantly influence usage patterns. Addressing these factors can potentially alleviate bottle necks within the fertilizer value chain.

3. The cluster-based approach provided a practical solution to coordination failures in extension programming, while also serving as a pertinent strategy for addressing challenges within the fertilizer value chain.

4. These findings have profound implications for policymakers, agribusinesses, and extension services. Understanding how these predictors affect spatial patterns can inform targeted interventions and strategies. For instance, fostering cooperative associations and facilitating credit access could potentially enhance clustering behaviour, leading to more efficient fertilizer distribution.

5. Additionally, acknowledging the role of education and geographical distance can aid in designing tailored extension programs and initiatives to optimize spatial patterns within the fertilizer value chain.

Abbreviations

AGRA	Alliance for Green Revolution in Africa
FVC	Fertilizer Value Chain
DAP	Diammonium phosphate
MOP	Muriate of Potash
GAS	Granular Ammonium Sulphate

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