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Impact of extension service on fertilizer application in agriculture: A case study in Kamrup district of Assam

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Abstract

The present study focuses on investigating the development of agriculture in the state of Assam through the prevailing methods of agricultural extension service. Due to the increasing demand for food grains and increasing population and also to raise farm income, both production and productivity aspects in agriculture occupy a significant importance. In that backdrop, the use of fertilizers play a crucial role in enhancing agricultural production and productivity by providing essential nutrients to the soil and thereby improving plant growth, crop yield, and overall soil health. Agricultural extension services provide information, knowledge, technical expertise regarding fertilizer application, crop based know-how etc. to the farmers. A field study was carried out in the Kamrup district of Assam to investigate the impact of extension service on fertilizer application and related aspects. A regression analysis was carried out to disentangle the effect of extension service on fertilizer application along with other control variables like farm size, irrigation, education etc. It is found that private extension service is the dominant source among the majority of farm households and private extension service has significant positive impact on the prime variable, i.e., fertilizer application. One worrying finding is that public source of extension service has very low penetration among farm households and has no significant impact as found in the study. Since most of the farm households are small and marginal farmers, public extension service should be revamped so that it reaches the resource poor farmers. The need of the hour is to cater the needs of those marginal and small size classes of the farm households through the public extension machinery.

Keywords: Farm household, extension service, fertilizer application, regression, Tobit model

Introduction

In a state like Assam, agriculture plays a pivotal role in the Economy as almost 70 percent of the rural population is engaged in agriculture for livelihood. The contribution of Agriculture to the State Economy is 23.02 percent.¹ About 50 percent of the workforce is engaged in agriculture in the State. The net cultivated area of the State is 28.11 lakh hectares which is about 88 percent of the total land available for cultivation in the State. The average operational holding in Assam is 1.10 hectare only. Again, more than 85 percent of the farm family is small and marginal farmers². So it is necessary to give this sector the utmost importance in the development perspective.

Again, with the increasing demand of food grains production, due to increase in population and decrease of cultivable land, the immense importance of use of fertilizers occupy a pivotal role in agriculture. Fertilizers play a critical role in enhancing agricultural productivity by supplying essential nutrients to the soil, thereby improving plant growth, crop yield, and overall soil health. In regions like Assam, where the agrarian economy is heavily dependent on rice and other food crops, the timely and appropriate use of fertilizers has a direct impact on food security and farmers' livelihoods. The Green Revolution in India during the 1960s

and 70s underscored the pivotal role played by chemical fertilizers in enhancing crop yields, especially nitrogen-based fertilizers such as urea (Sharma, 2012)^[7]. In an earlier study (Desai & Namboodiri, 1997)^[4], it was pointed out that fertilizer use accounts for more than 50% of yield growth in agriculture India. However, the benefits of fertilizers are highly dependent on the righteous combination, dosage, timing, as well as farmers' awareness and proper training—often facilitated by agricultural extension service. Effective and balanced fertilizer application is not only a matter of availability but also of awareness, education, and technical guidance—domains where agricultural extension services play a vital role. Extension machineries, agents, through on-field demonstrations, farmer- training and advisory services, serve as critical intermediaries between scientific knowledge and grassroots practice. As (Anderson & Feder, 2007)^[1] points out, extension services are a key institutional mechanism for improving agricultural productivity by encouraging and promoting technology adoption, including optimal fertilizer use. Without access to proper information and knowledge farmers are likely to underuse or misuse fertilizers, leading to low yields and diminishing soil fertility. In the Indian context, Swanson *et al.* (1997)^[8] emphasize that targeted extension programs have significantly contributed to educating farmers on soil testing, nutrient deficiencies, and fertilizer recommendation

¹ Economic Survey, 2023-24 (Assam)

² Economic Survey, 2023-24 (Assam)

protocols. For instance, programs like the Soil Health Card Scheme, implemented across Indian states including Assam, enabled farmers to receive customized fertilizer recommendations based on soil test results—disseminated largely through extension officers, Krishi Vigyan Kendras (KVKs), and ATMA projects. In the context of Assam, a study by (Sarma & Deka, 2015) ^[6] highlights that fertilizer application remains lower than the national Indian average due to factors like lack of awareness, limited availability and higher costs. Extension services have been instrumental in narrowing this gap by educating farmers on the balanced use of fertilizers, integrating organic and inorganic inputs, and promoting soil health through schemes like Soil Health Card Mission and Integrated Nutrient Management (INM). In another study in Assam, (Das & Borthakur, 2018) ^[3] find that a majority of small and marginal farmers lacked scientific knowledge of fertilizer application prior to engaging with public provisioning of extension services. Their study shows that regular field visits by agricultural officers and KVK-led training programmes have improved knowledge and adoption of balanced fertilizer application in a significant way. This resulted not only in improved crop yields but also in reduced input costs and better soil health management. Kumar *et al.* (2020) ^[5] highlight the emerging role of ICT-based extension tools in providing alerts and advisories on time regarding fertilizer scheduling, especially in flood-prone and rain-fed regions in Assam. Bhattarai *et al.* (2020) ^[2] explain that knowledge dissemination on

fertilizer use can significantly improve nutrient management, thereby increasing yields and reducing environmental degradation. In Assam, the role of Krishi Vigyan Kendras (KVKs), ATMA projects, and NGO-led farmer training programmes has been pivotal in enhancing farmers' knowledge about fertilizer application and sustainable nutrient management practices. Overall, fertilizers remain a cornerstone of modern agriculture, and their judicious use, enabled by effective extension services, can lead to more resilient, productive, and sustainable farming systems in Assam.

Fertilizer contains generally three important nutrients namely, Nitrogen (N), Phosphorous (P) and Murate of Potash (K) and as used conventionally NPK (in Kg) consumption per hectare of Gross Cropped Area (GCA) is used in the present study to assess the impact of extension service on fertilizer consumption. Extension services generally provide information, knowledge, technical expertise regarding fertilizer application, crop based know-how etc as discussed earlier. Proper dosage of fertilizer can enhance the production and productivity of farm produce. In that case, knowledge on fertilizer invariably develops farming practice and technique. The following table shows a comparison of fertilizer consumption in agriculture between Assam and India as a whole. It clearly reflects that from 2012 to 2021, Average in Assam is far below than All India average.

Table1: Comparison of Consumption of Fertilizer (N+P+K)- (Kgs./ Hectare)

State	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Assam	65.7	88.8	90.2	44.8	74.6	63.5	74.0	61.3	56.81
All India (average)	130.8	118.5	127.5	130.7	124.4	127.9	132.1	127.8	137.15

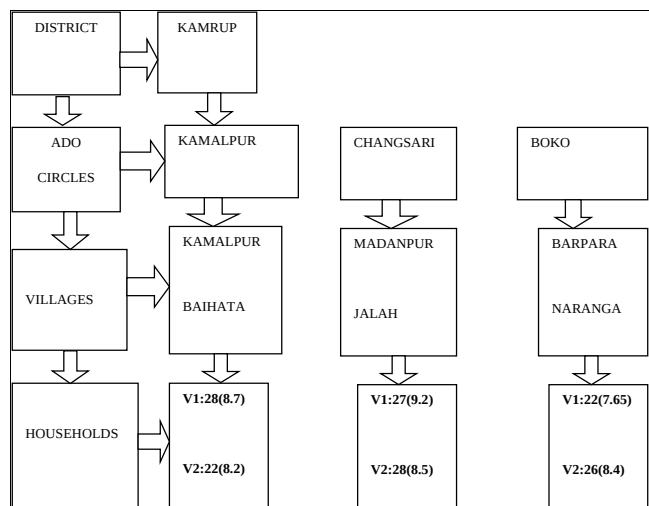
Source: Handbook of Statistics on Indian States 2022-23

Given this context, the present study tries to disentangle the effect of extension service on fertilizer application for various farm practices thereby measuring the importance on production and productivity. The primary objective is set as to investigate the impact of extension on fertilizer application in agriculture. A structured questionnaire was used to investigate how the farm households obtained those services and other related aspects like nutrient requirements, application methods, and minimization of negative environmental consequences and also about available Government schemes on soil health, integrated nutrient management.

Research Methodology

Since, secondary data was not adequate to get a clear picture about the status of fertilizer application and other related aspects as explained earlier, primary data collection was necessary to serve the research purpose. The field survey was carried during January to May, 2022. To collect primary data, a multi stage sampling technique was adopted to randomly collect the sample, i.e., farm households, of the study. Assam has six distinct agro-climatic zones and our

study area Kamrup district falls under North Bank. In the first stage, the district has been selected purposively to conduct the sample survey. While, in the second stage, three Agricultural Development Officer's (ADO) circles was selected purposively from the district and then from each ADO circle two villages were selected randomly as field study locations. Thus a total of 6 villages have been selected in that process. The final sampling unit of our study i.e., the household owning or operating on agricultural land have been selected using random sampling technique. In each village, sample size ranged from approximately 7 to 10 percent of farm households and in that process, a total of 153 sample households have been selected and interviewed. The multi stage sampling design is explained below in figure1. Both rice and horticultural farm practices were taken into consideration while collecting the sample so that agricultural practices are captured across regions. Informed sources like District Agriculture Officer, ADOs and VLEWs were consulted for selecting those ADO Circles for field investigation but the final sample was collected at random. The following Fig1 describes the sample collection process in a multi stage sampling technique.



Notes: 1. V1-village1, V2-village2, V3-village3

2. Figures within () represent percentages of households in the village in the sample

Fig 1: Selection process of the sample

Table 2: Percentage distribution of sample households according to size classes of ownership holding and operational holding#

Ownership holding (in hectare)	Size classes (in percentage)	Operational holding (in hectare)	Size classes (in percentage)
Nil	12.07	Nil	0
0-1	65.52	0-1	56.4
1-2	15.52	1-2	31.5
2-3	1.82	2-3	3.4
3-4	3.45	3-4	6.9
4-5	1.62	4-5	1.8
5-6	-	5-6	1.7
Total	100	Total	100

Source: Field study

[# Operational Holding=land owned + land leased in-land leased out-fallow land]

Table 3: Farm size wise access to extension service (in percentage)

Farm Size	(in hectare)	0	1	2	3	4	5
Public Extension Service (PUBEXT)	In percentage	12	14	18	15	22	
Private Extension Service (PVTEXT)	In percentage	67	72	65	52	48	

The following table3 shows farm size wise access to extension service.

Source: Field Study

It is evident from the table that public provisioning of extension service shows a dismal performance among the farm households. The penetration of Private extension service is far better than public extension service. So, we can conclude that small and marginal farmers are bypassed by the public extension machinery. Again, the following

Results and Discussion

From the collected samples, the followings data has been compiled to get an idea about the various size classes of farm households. Again, according to size classes, their source of extension service is calculated from the data.

Distribution of sample households in terms of Ownership Holding and Operational Holding:

The distribution of the sample farms according to their size of ownership holding and operational holding are presented in the following table2. As reflected, percentage of small farmers in terms of both ownership holding and operational holding is the largest in our sample. In other words, most of the farm households own and operate in small amount of land in our sample. In the size classes of 0-1 and 1-2 hectares, percentage of farmers with ownership holding are 65.52 and 15.52 respectively and in terms of operational holding, these are 56.4 and 31.5 percent respectively. The average size of operational holding stood at 1.6 hectares among the sample farm households.

data explains how the farmers have acquired variety of fertilizer related information, knowledge and other related aspects from both public and private sources of extension services. Here, categorization of extension service is done on the basis of NSSO Situation Assessment Survey, 2003. It is evident from the following table4 that penetration of public extension service is very low among the farm households for information and knowledge on fertilizer related aspects and private sources of extension service, particularly, input dealers capture the majority of farmers. Among public provisioning, VLEWs stand at mere 13 percent followed by Training and Extension officer/ any Government agents. Among private sources, after input dealers, farmers consult fellow farmers for the aforesaid purpose.

Table 4: Percentage Distribution of Farmers Accessing Extension Service by Source for knowledge on fertilizer

Sources of extension services	Overall percentage	Sources within public and private extension services	Individual Source wise Overall percentage	Application technique	Dosage	Other aspects (soil health, nutrition management etc.)
Public	19	VLEW	13	26	15	10
		Extension officer/any govt. agents	3	5	7	2
		Training	3	18	10	8
		Radio	1	0	0	0
		KCC/ helpline	1	0	0	1
Private	76	Local input dealer/trader	62	59	54	57
		Fellow farmers	17	19	15	21
		FMC/progressive farmers	1	1	1	1
		Books/any other printed materials	1	0	0	0

Source: Author's own calculation from field study data

However, to get an idea about the impact of extension service on fertilizer application and related aspects, regression analysis is necessary. In the following section, regression model is developed and analyzed.

Regression analysis

As described above about the importance of fertilizer in enhancing both production and productivity in agriculture, it is very much essential to investigate how the existing forms of extension services are working to cater the needs of the farmers. This study tries to disentangle the effect of extension services on fertilizer application for both rice and horticultural farm practices. Fertilizer contains three important nutrients namely, Nitrogen (N), Phosphorous (P) and Murate of Potash (K). As used conventionally NPK (in Kg) consumption per hectare of Gross Cropped Area (GCA) is used in this study to assess the impact of extension service.

Probable variables which may influence fertilizer application

Independent Variable

Access to Extension service: Farm households who are taking advice on fertilizer application from various sources are pooled under Public and Private Extension services. Again whatever may be the source, farmer taking advice or not taking advice are kept under Overall access to extension service. So extension services on fertilizer related knowledge taken by farmers are categorized under Overall access to extension service for fertilizer (ALEXT_F), access to Public extension service for fertilizer (PUBEXT_F) and access to Private extension service for fertilizer (PVEXT_F).

Control variables

Farm Size (FS): It is a matter of empirical investigation whether farm size influences fertilizer application or not since small farmers also opt for HYVs where fertilizer application is necessary to get improved results. So, it may not be assumed a priori that large farmers only use more fertilizer than small farmers do. It is also dependent on crop varieties to be grown. Here, operational holding in hectare has been used to measure farm size.

Extent of Irrigation (IRGA): Fertilizer application and provision for irrigation are crucial factors for better farm produce they are related with each other in a positive way. Better irrigation facility may induce farmers to use fertilizer. So the coefficient of extent of irrigation may hold a positive sign. It is defined as the proportion of total irrigated area to gross cropped area.

Access to Finance (FIN): Easy access to finance immensely help farmers to purchase various farm equipments and other essential inputs for better farming, thereby raising farm output. Access to finance (FIN) is constructed as a dummy variable. Its value is 1 if the farmer has access to institutional credit and value is 0 if otherwise. A positive sign of the coefficient of the variable FIN is expected. As fertilizer purchase requires adequate credit, its coefficient is expected to bear a positive sign. So it implies that farmers with access to institutional credit may purchase more fertilizer.

Education (EDN): The effect of formal education is captured by setting the educational attainment of the head of the household in a dummy form, i.e., 0 for not literate and 1 for literate. This variable is written as EDN. It is believed that farmers educated with conventional education or being literate have significant impact on decision making in the agricultural practice. However, the long term experience and 'learning by doing' of farmers are also deciding factors. So, it is a matter of empirical investigation and as such, the sign of the coefficient of education can not be assumed a priori. The dependent variable (Y), i.e., NPK consumption per hectare of GCA is formulated as three formulations. They are Overall access to extension service for fertilizer (ALEXT_F) in formulation1, access to Public extension service for fertilizer (PUBEXT_F) in formulation2 and access to Private extension service for fertilizer (PVEXT_F) in formulation3 respectively.

For Overall access to extension service

$$Y = f(\text{ALEXT}_F, \text{FS}, \text{IRGA}, \text{EDN}, \text{FIN})$$

For access to public extension service

$$Y = f(\text{PUBEXT}_F, \text{FS}, \text{IRGA}, \text{EDN}, \text{FIN})$$

For access to private extension service

$$Y = f(\text{PVTEXT}_F, \text{FS}, \text{IRGA}, \text{EDN}, \text{FIN})$$

Functional Specification of the Model

The dependent variable, i.e., NPK consumption per hectare of GCA takes values either zero (0) or values which are greater than zero. A zero value means that farmer is not applying fertilizer. It implies that the lower end of the dependent variable is bounded at 0. We have nine (9) such values. However, there is no such limit in the upper end. Since we have got cluster of observations at zero (0), Tobit model with left censoring is the appropriate technique here instead of linear regression. So we have constructed the Tobit model using the latent variable Y_i^* which may take any probable value which is not always observable. The three formulations are as under-

$$Y_i^* = \beta_0 + \beta_1 \text{ALEXT}_{Fi} + \beta_2 \text{FS}_i + \beta_3 \text{IRGA}_i + \beta_4 \text{EDN}_i + \beta_5 \text{FIN}_i + U_i$$

$$Y_i^* = \beta_0 + \beta_1 \text{PUBEXT}_{Fi} + \beta_2 \text{FS}_i + \beta_3 \text{IRGA}_i + \beta_4 \text{EDN}_i + \beta_5 \text{FIN}_i + U_i$$

$$Y_i^* = \beta_0 + \beta_1 \text{PVEXT}_{Fi} + \beta_2 \text{FS}_i + \beta_3 \text{IRGA}_i + \beta_4 \text{EDN}_i + \beta_5 \text{FIN}_i + U_i$$

Here, U_i s are random disturbance terms which are assumed to be distributed with zero mean and constant variance. The dependent variable Y_i is linked with the latent variable as under where-

$$Y_i = 0 \text{ for } Y_i^* < 0$$

$$= Y_i^* \text{ for } Y_i^* \geq 0$$

The maximum likelihood estimates of the parameters are obtained using STATA software. Estimated results are shown in the following table. Breusch-Pagan Test was performed to detect the problem of Heteroscedasticity in the data set before estimation of the parameters in the aforesaid model. The test confirms the presence of heteroscedasticity in the three formulations of the model and these are corrected by estimating the White heteroscedasticity consistent Robust Standard Error.

The results of our regression analysis are shown in the following Table 5. It is found that the coefficients of the variable Overall access to extension service for fertiliser (ALEXT_F) in formulation1, access to Private extension service for fertilizer (PVEXT_F) in formulation3 are found to be statistically significant at 1 percent and 5 percent level respectively. However, the coefficient of the variable

Access to Public extension service for fertilizer (PUBEXT_F) in formulation2 is not significant in the analysis. Thereby, we can conclude that access to extension service (as a whole) has a positive impact on fertilizer application and related aspects. However, public extension service fails in influencing or providing sufficient knowledge to the farmers in fertilizer application to the desired extent. Private extension service providers, particularly local input dealers are occupying a prominent position among the farm households. Since farmers purchase fertilizers and other inputs from the input dealers; along with those products, farmers take related advice from them. Among the control variables, the coefficients of extent of irrigation in all three formulations are found to be significant at 1 percent. So, irrigation plays a crucial role in fertilizer application.

Table 5: Results of left censored Tobit regression for NPK per hectare on GCA

Heteroscedasticity test	Formulation1	Formulation 2	Formulation 3
	Breusch-Pagan test Chi2 [1] = 132.27 Prob. = 0.0001 Result: Presence of heteroscedasticity	Breusch-Pagan test Chi2 [1] = 131.91 Prob. = 0.0001 Result: Presence of heteroscedasticity	Breusch-Pagan test Chi2 [1] = 137.71 Prob. = 0.0001 Result: Presence of heteroscedasticity
Variables	Estimates of coefficient/values	Estimates of coefficient/values	Estimates of coefficient/values
ALEXT _F	85.66(46.76)***		
PUBEXT _F		30.74(23.88)	
PVEXT _F			85.33(42.76)**
FS	10.32(13.75)	12.67(21.91)	11.65(18.24)
IRGA	130.15(79.82)***	178.54(83.78)***	134.62(77.86)***
FIN	39.47(34.88)	42.58(39.28)	72.42(63.86)*
EDN	2.84(12.72)	1.28(10.78)	1.86(9.07)
Constant	-111.63(48.21)**	-84.47(46.87)	-121.65(49.07)**
Pseudo R ²	0.0532	0.0557	0.0524
F [5,148]	43.27***	40.43***	39.24***

Figures in () and [] represents Robust Standard error and Degrees of freedom respectively. (***, ** and * represents significant at 1, 5 and 10 percent level.)

Conclusion

Most of the farm households in Assam are small and marginal farmers and they need proper attention from the Government extension machinery. The present case study in the Kamrup district of Assam depicts a dismal scenario of public extension services. In a world of modern farming system, those resource poor farmers need appropriate information, knowledge on technical things of fertilizer application etc. along with other vital farming techniques. In this regard, public extension service system needs to be strengthened to boost the overall agricultural development of the State.

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