Investigating Allocative efficiency, Cost efficiency, Technical efficiency using Stochastic Frontier Analysis (SFA) of Groundnut Farm Households: Evidence from a case in India

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Abstract

This paper investigates the economic efficiency of groundnut farm households in the India through a case study of Sikhar block of Mirzapur District (Uttar Pradesh). The efficiency approach is conducted not at the farm level only, but also considered households characteristics like age, farming experience and educational status of the household to capture its importance in farm production. Stochastic frontier analysis has been used to evaluate technical, allocative and cost efficiency. The results indicate that Technical inefficiency is fairly high indicating that access to technology is a severe constraint for most farm households. The cost of scale inefficiency including technical and allocative inefficiency is found to be high. Results of this study have concluded that the efficiencies are varying across the different farms due to some efficient variables i.e. farmers' education level, farming experience, age and land size. Younger farmers were found to be more inefficient as compared to aged farmers and on education level, farmers with large land size were found to be more efficient. The significant value of the coefficient of the farming experience indicates that farmers, who have more experience in farming, were more inefficient, contrary to our a priori expectation. It could be due to that the experienced farmers have been habituated to use conventional methods of farming and not ready to adopt new technology. The major source of inefficiency is allocative inefficiency which reflects failure to respond to price and resource scarcity in households' decision-making. This study shows that the significant part of allocation efficiency cost came from age, level of education, farming experience and size of land indicating that there is a need to analyze at household level rather than the farm level.

This study suggests that imperfection in education, age, and farming experience kick to reduce productivity and lower the efficiency in the groundnut farm households. Agriculture being dominant occupation, results of the study reflect that the efficient determinants have the potential source of efficiency and this could be relevant for policy formulation.

Keywords: Allocative efficiency. Cost efficiency. Technical efficiency.

1. Conceptual Background

Agriculture is the predominant occupation in India and almost 70 percent populationa derive their livlihooh from agriculture. There is dominance of small farms and dependence on conventional methos is still high. This study relates with investigating Allocative efficiency, Cost efficiency, Technical efficiency using Stochastic Frontier Analysis (SFA) of Groundnut Farm Households: Evidence from a case in India. Groundnut (Arachis hypogaea) is a species in the vegetable or "bean" family Fabaceae. It has many other local names like earthnuts groundnuts, goober peas, monkey nuts, dwarf nuts, pig nuts etc. History of groundnut shows an excursion from South America to Asia, east over the Atlantic Ocean and back again to North America. Probably/ presumably, the origin of groundnut plant is in Peru or Brazil in South America. Dr. George Washington Carver is considered by many as the father of the groundnut based business. He suggested to ranchers that they should rotate their cotton plants and cultivate groundnuts (Choudhary, Rathore, & Sharma, 2017). Groundnut is one of the most common oilseed crops in India. It has been called the 'King of oilseed crops' and the almonds of the poor. About 45 to 55 percent oil is found in the grains, which are used as food items. The oil content of groundnut has 82 percent liquid, lubricating oleic and linoleic acids. The oil is mainly used in the production of vegetable ghee and soap, along with manufacture of cosmetics, shaving cream, etc. Groundnut is a good and inexpensive source of botanical protein with a protein content of 28 to 30 percent. Groundnuts contain 1.3 times more protein than meat, 2.5 times more protein than eggs and 8 times more than that in fruits (Johnston & Buller, 2005), (Han, Bourgeois, & Lacroix, 2009), (Akhtar, Khalid, Ahmed, Shahzad, & Suleria, 2014), (Ghuman, Mann, & Hira, 1990). The presence of high-quality protein makes it easily digestible. Groundnuts contain thiamine, riboflavin and nicotinic acid, and sufficient amounts of vitamin E. This is also a source of minerals like phosphorus, calcium and iron. The nuts are used as roasted, fried or eaten raw, or used for making sweet and salty dishes. Milk and curd are also prepared from groundnuts (Arya, Salve, & Chauhan, 2016). The green vegetation of groundnuts, obtained after digging, is fed as fodder to animals in the form of silage or green. The cake, after extracting oil from the nuts is used as a nutritious animal feed and organic fertilizer. It contains 7 to 8 percent nitrogen, 1.5 percent phosphorus and 1.5 percent potash. Nitrogen fixing bacterium Rhizobium is found in its roots which stabilizes the level of nitrogen in the ground (about 80-200 kg per ha) (Arya et al., 2016), (Janila, Nigam, Pandey, Nagesh, & Varshney, 2013). Therefore, groundnut cultivation improves the physical condition of the soil, and by including it in the crop cycle, soil fertility increases. This crop is also considered to be the best means to prevent soil erosion (Sukataatmaja, Sato, Yamaji, & Ishikawa, 2002). In this way, groundnut is a multifaceted commercial crop. In India, 81 percent of the total groundnut production is used for extracting oil, 12 percent as seeds, 6 percent as food, and the remaining 1 percent for exports. Indian groundnut is grown on 31 million hectares, almost like the area of Nigeria. Indian peanuts are consumed in more than 50 countries and are also available throughout the year. The crop is cultivated in two cycles and harvested in March and October. There are several other inter-cropping cycles that make Indian groundnut a major source of supply (https://www.agrocrops.com/groundnut-division.php/2020). Groundnut production in India is facing the high costs of production coupled with low productivity. At the current level production cost of groundnut, gradually increases due to the high weed management cost (Korav et al., 2018), (ICAR, 2018). Profitability and cost of production are an important consideration for farmers involved in the cultivation of any crops. Consequently, production technologies and operational constraints are important elements to increase the productivity of groundnut which will finally raise the farm income for cultivators and reduce cost of production (Afreen & Haque, 2014), (Pokhrel, 2010), (Alchian & Demsetz, 1972). The manual labour, land, seed, tillage, fertilizer, herbicides etc. are the items for accounting the cost of production of groundnut. In this study, profitability of groundnut production stand for cost and return per unit was calculated to measure average profitability. Cost of production for agriculture products involves estimating economic costs and revenues associated with the particular agriculture product.

Agriculture and allied activities contribute around 14 percent of India's GDP and approximately 50 percent of the total workforce is involved. In the current scenario, India is one of the largest producing countries for the major staple food of the world and it is showing a significant improvement in kilograms per hectare per annual. The significant transformation has occurred in Indian agriculture over the last few decades. The green revolution 1966-1969 was a major technological transformation, which made a lasting impact on Indian agriculture structure. Agriculture plays an important role in the development of the Indian economy and here, there is no need to elaborate it. However, its role needs to be re-oriented in light of changing the innovative and structure of the various inputs to fulfill the new coming challenges and explore opportunities. However, when we analyze the growth status of agriculture in terms of innovation, modern infrastructure, farmers' skill level and technological advancement, more needs to be done to make these sectors stronger. It requires an advance shift in our approach and idea for transforming change in agriculture.

Further, Indian agriculture is in the nexus of numbers of challenges enhancing productivity followed by competitiveness, rural growth improvement, water resource and irrigation management, facilitating agricultural diversification to higher value commodities, skill development of farm households. Although India has achievements in the agriculture sector, through impressive performance in different areas but remain, the performance is lower than the potential level. There are many causes behind it, but inefficiency level in different fields of agriculture is one of the most important causes to make this sector underperformance. Efficiency is driven by various factors in a different field. Indian farmers have missing the art of technological advancement and the modern method of farming. In an advanced economy, the agriculture sector is moving to perceive modern technology to reduce the cost of production and make it a very significant part of their economy. It saves time, environment, more yield, reduces cost and improve farms household status. Indian farmers are still continuing to use the convention-farming system, but they are able to utilize available resources at the maximum level. They do not have sufficient skills, knowledge, experience and idea about the existing resources. Efficiency is the ability to avoid wasting inputs in the form of materials, money, energy, and time in producing the desired result in any field. In other words, it is the level of ability to make something function successfully without any waste.

Efficiency can be measured for an individual farm or a group of farms, at any structured system. It does reflect the ultimate purpose for the inquiry in different fields. If, for example, the purpose is to compare productivity between farms, then micro-based measures are required. The desired purpose may vary, but the measurement issues associated with deriving the different indicators might be the same. In India, agriculture efficiency is at the centre in the debates of scientists, policymakers and major concerning sector and they are doing additional research and development on statistics to perceive target efficiency level. In this context, enough statistics and literature are required to visit towards achieving macro and micro level agriculture sector efficiency. Measurement of agricultural productivity and efficiency is now a new idea, but it can be traced back from the various theories given by classical economists, which made essential contributions towards developing a better measuring, understanding and analyzing agriculture efficiency and productivity. Only a small part of researches have addressed on this issues and there are few work which focused about this challenges specially for India on the basis of primary data to find major factors and model to implement the appropriate approaches to compile nationwide factors of agriculture efficiency and productivity. There are number of factors including lack of sound data, weak infrastructure, farm households' skill in India limit to perceive a potential level of efficiency and productivity. Productivity measurement has traditionally assumed the inexistence of technical inefficiencies in the production process. Starting with Nishimizu & Page (1982), followed by Fare et al. (1989), the research community has been placing additional emphasis on the decomposition of productivity changes into a technological change component and an efficiency component. This distinction is important. As noted by Grosskopf (1993), if inefficiencies exist and are ignored in the measurement of productivity, productivity growth no longer necessarily tells us about technical change and the policy decisions based on these indicators may be flawed. A better understanding and measurement of efficiency in agriculture is required in the context of lower availability of key resources and production factors, such as land or water in adequate quantity and quality.

This literature and analysis gaps have been undertaken in the context to measurement of groundnut farms efficiency level at the block level to know the real scenario and use findings to improve the farmers efficiency and status. It would also be useful in identifying the challenges associated with implementation to farm households. Indian farmers should not just be efficient in their production activities, but also responsive to technical efficiency, so that the scarce resources could be utilized efficiently to increase productivity. It will ensure an uninterrupted and sufficient supply of groundnut and its products. Furthermore, efficiency gains will have a positive impact on raising farm income to improve farmers' status.

Lagakos and Waugh (2018) argued with the help of stochastic production function in a research work, which shows that how cross country productivity differences are larger in agriculture crop production than non-agriculture. Here, sector-wise heterogeneity in workers was found as a major factor responsible for differences. A study conducted in Kenya found that Bambara groundnut production is technically inefficient in Western Kenya. Therefore, improvement in extension factors in crops producing farmers will improve productivity and farmers status (Korir, Serem, Sulo, & Kipsat, 2001). Research work has evaluated technical efficiency by using a stochastic frontier function for a group of 282 groundnut farm households for two region of Myanmar to know the efficiency level. The average level of technical efficiency was estimated 59 %, it suggests that there is possibility to improve technical efficiency through the better use of available resource. Age and education level of households are found significant variables in improving technical efficiency (Win, Kitchaicharoen, & Chaovanapoonpho, 2009). In a study, farm wise profit inefficiency of basmati rice producers was calculated with the help of profit frontier in Punjab, India. The average level of inefficiency at farm resources and price level recorded 28%, with a wide range (5%-87%) and due to this inefficiency per hectare loss was estimated Rs.1,222. Education level, non-agriculture employment and lack of credit, improper use of water and fertilizer were found major significant variables for profit inefficiency. Further, it was found to get Rs.240.00 million extra profit could be enhanced by 25% reduction in profit loss (Ali & Flinn, 1989). A research work had been conducted in Sudan to know the level of technical efficiency and major factors responsible for inefficiency and improvement level through Gezira scheme of Sudan groundnut farmers. Average technical efficiency was found to be 65% of groundnut producers, which shows that production of groundnut could be improved by 35% at the existing level of inputs, by just improving farmer efficiency. Farmers' age, education level, seed sowing date, irrigation strategy and total number of workers were found major associated factor to improve groundnut production. The size of family and the experience of the farmers were found to be most significant factor for the technical efficiency of groundnut farmers in Gezira scheme in Sudan. It has been suggested that improvement in education and extension services will enhance the technical efficiency of groundnut farmers (Babiker O. Mahgoub, Sara A.E. Ali, n.d. 2017). Work has been conducted to examine the profitability and economic efficiencies of groundnut production in Benue state, Nigeria. Groundnut was found to be moderately profitable. Farmers were found to be technically inefficient and average farmers spent 28% above the minimum cost of production. Annual income, age and household size were the major determining factor for technical and allocative inefficiency (Ani, D. P., Umeh, J. C., Weye, 2013). Pradhan and Mukherjee (2017) made an inference with the help of a stochastic frontier function to estimate the technical efficiency of agricultural production of India, where age, education status, irrigated area and household family size were found significant factors in resource utilization efficiency. Ghosh and Raychaudhuri (2015) have discussed technical and cost efficiency of rice producing states using stochastic frontier function for cost and production function.

2. Problem of the Study

The present study set out to identify farm-specific characteristics and to analyze the technical efficiency of groundnut growers that explain variation in the efficiency of individual farmers. The relationship between technical efficiency and household characteristics has not been well studied in India at the block level. In this study, groundnut producers are technically inefficient if there is a scope for a higher level of output, which is technically attainable with existing inputs or when the observed output level can be produced by using fewer inputs. An understanding of these relationships could provide policymakers to set programs that contribute to improving the technical efficiency of the groundnut production potential of the nation. To increase groundnut production and improve production technology is expected to enhance productivity and farmers' income in the country where around 68 percent of the population lives in rural areas and depends primarily on agriculture for its livelihood. Therefore, this study attempts to examine how the farmers use different factors of production to improve cost efficiency in groundnut production and how it relates to manual and chemical weed techniques. Weed control methods differ across different villages and farmers of Sikhar Block, it is therefore imperative to examine inefficiency in terms of weed control methods of the groundnut farms, and examine whether there exists a relationship between cost inefficiency in case of groundnut production across the different groups of farmers.

3. Methodology

The present section deals with research methods used in the study which has been categorized in different groups like study area, sampling techniques, methods of data analysis etc.

3.1. The study area

Mirzapur is located at 25.15°N-82.58°E. Mirzapur district is one of the 75 districts of Uttar Pradesh situated in northern India. The district is bounded on the north by Sant Rabindas Nagar and Varanasi districts, on the east by Chandauli district, on the south by Sonbhadra district and on the northwest by Allahabad district. The district occupies an area of 4521 square km. Mirzpur city is the district headquarters. Mirzapur district is a part of Mirzapur division. This district is famous for the Vindhyavasini temple in Vindhyachal and several tourist attractions like waterfalls and dams. It consists of several Ghats where historical sculptures are still present. During the Ganges festival, these Ghats are decorated with lights and earthen diyas. It is currently a part of the Red Corridor. It was once the largest district in Uttar Pradesh until Sonabhadra district was separated from Mirzapur in 1989. According to the 2011 census Mirzapur district has a population of 2,494,533 roughly equal to the population of Kuwait or the US state of Nevada. This gives it a rank of 174th in India (out of a total of 640 district). The district has a population density of 561 inhabitants per square kilometer (1,450/Km^2) Its population growth rate over the decade 2001-2011 was 17.89%. Per annum. Mirzapur has a sex ratio of 900 females for every 1000 males, and a literacy rate of 70.38%. Female Literacy rate here is 54% (https://en.wikipedia.org/wiki/ Mirzapur_district/24/07/2018).

The major economic activity of this zone is agriculture. The major food crops cultivated in this area are rice, wheat, groundnut, maize, sorghum, cowpea, potato etc. while cash crops

include chili, vegetable pea, sesame etc. Major livestock are cow and goats, sheep animal and poultry farms. Mirzapur district has been divided in four tehsil (Sadar, Marihan, Lalganj and Chunar) and there are total 12 blocks in these four tehsil of Mirzapur district. Groundnut is a major crop of farmers in Sikhar block and farmers use manual and chemical methods to remove unwanted plants from groundnut crop. Therefore, Sikhar block has been selected for this work to compare the manual and chemical weed management cost to evaluate the cost effectiveness. Tehsil and block wise numbers of villages have been given in following table:

Table 1: Total Blocks & Tehsil in Mirzapur District, India

S. No.	Blocks	Tehsil	No of Villages	S.N.	Blocks	Tehsil	No of Villages
1	Chhanbey	Sadar	256	7	Hallia	Lalganj	210
2	Kon	Sadar	83	8	Lalganj	Lalganj	209
3	Majhawa	Sadar	55	9	Jamalpur	Chunar	229
4	City	Sadar	178	10	Narayanpur	Chunar	214
5	Pahari	Sadar	134	11	Rajgarh	Chunar	161
6	Patehara	Marihan	139	12	Shikhar	Chunar	99

Source: Mirzapur District Profile/2018, Uttar Pradesh Government, India

3.2. Sampling Method

This study uses a case study of Sikhar, block of Mirzapur District, Uttar Pradesh in India using cross-sectional analysis. Data were collected through face to face interviews with the help of a pre-structured schedule in November, 2018. The schedule was Investigating designed in English and translated in Hindi (Devnagri Script) to make it easy for rural farmers to understand. This tool was finalized after proper review, discussion with Indian scientists and pilot survey. It includes closed-ended questions to specific study in a structured direction. This schedule was generated in the multiple-choice format so that respondents can select only appropriate answers, which is the best, describe their opinion or attitude on the specific issue. The schedule contained a couple of sections to cover different aspect of

objective of the study, followed by basic information on personal characteristics of the farmers including age, gender, education level, years of farming experience and farming practices, farmers issues related to availability of workers, farmers' skill, pesticide handling practices and use of personal protective equipment during pesticide application, awareness about application of fertilizer, chemical in farming and its importance and last but not least it generated a macro table to record data related to inputs cost and product from beginning to harvest of the crop. The population of this work was groundnut farmers. As the climate nature of the block is remaining same, therefore, 11 out of the 57 villages were randomly selected for the primary survey. A household list of groundnut farmers was prepared from all 11 selected villages then 205 farmers were interviewed to get accurate information. Stochastic frontier analysis has been used this work to know the actual scenario.

3.3. Stochastic Frontier Analysis (SFA)

Education, training, skill, age and experience may have productive value, because it enables the manager of a firm to produce a greater quantity of output from the same amount of inputs

and it also helps in better allocation of available resources. Generally, the correlation between education and workers' earnings is used to ascertain the economic benefits of education. Ever since T. W. Schultz reintroduced the concept of human capital in his presidential address to the American Economics Association and emphasized the need of extensive study in this matter; the literature in this field have increased tremendously in both volume and content. As we move away from the wage sector, the value of education becomes more difficult to determine. Using data on family consumption patterns, Michael (1972) tries to present that

education can increase a person's 'full income' even if money income remains constant. He believes that it is the ability of education to increase the productivity of the time spent in household production. The productive effects of education for the self-employed are now under study by many economists. Farrel had started to use efficiency in relative terms on that basis the efficiency of decision-making units, which can be compared to each other. Then he explained technical efficiency, allocative efficiency, and economic (cost) efficiency.

Stochastic Frontier Analysis (SFA) and Data Envelop Analysis (DEA) are two most frequently used methods for efficiency estimation. SFA is a most frequently used parametric approach and DEA is a most frequently used nonparametric approach to provide efficiency evaluation (Blatnik, Bojnec, & Tušak, 2017). SFA and DEA approaches are different from each other because they use different approach to evaluate frontier function. The SFA approach use quotients for measuring efficiency based on econometric evaluation of stochastic frontier functions, while DEA measures efficiency score based on linear programming methods. Stochastic frontier analysis has been used to measure efficiency value for this work. Stochastic frontier analysis (SFA) provides efficiency estimates or efficiency scores of individual producers. Thus, one can identify who needs intervention and corrective measures. Since efficiency scores vary across the producers, they can be compared with farmers' characteristics like farmers' age, education status, farming experience, farmland size (extension) etc. On this basis, one can identify the source(s) of efficiency. A production function uses only input and output quantity data, while profit, revenue and cost frontiers use input and output quantity data with its price data. It explains technical efficiency, allocative efficiency and cost-efficiency. Technical efficiency refers to the ability to minimize input use in the production of a given output vector or ability to obtain maximum output from a given input vector (Kumbhakar, Wang, & Horncastle, 2015). Koopmans (1951) has defined two special case of technical efficiency first being output-oriented and second being input-oriented. A feasible input vector is technically efficient if, and only if, no reduction in any input is possible, hold the output vector fixed that is input oriented measure of technical efficiency. Second a feasible output vector is technically efficient, if and only if, there is no possibility of increase in output with holding the fixed input vector. This is output oriented measure of technical efficiency. Technical efficiency can be measured in different cases, like single output-frontier measure or multiple output-frontier function. In single output production frontier, producers use multiple inputs to produce a single output and similarly in multiple output production functions, producers use various inputs to produce multiple outputs. Technical efficiency in this term has been used with the help of the production frontier by Iso-quant in both single and multiple output cases. But there are fairly weak standards due to lack of cost minimization behavior objective. Cost minimization behavior approach provides, cost frontier function and its associated system of cost minimizing input demand equations that will provide a standard measure against to measure cost efficiency, it is a more accurate input oriented standard against which to measure producer performance. So, to minimize cost, the standard against which their performance is evaluated shifts from the production frontier to the cost frontier and it will explain that the achievement of input-oriented technical efficiency is necessary but not sufficient for the achievement of cost-efficiency. This is because only technical efficient producers could use an inappropriate input mix, given with input prices. So, the measurement of cost efficiency is the ratio of minimum cost to actual cost or it is a ratio of minimum cost to actual cost and the value of cost efficiency is between zero and one, getting the upper value shows proper application of cost minimizing input vector and lower value shows inverse case. The cost minimization criterion is most widely used in empirical applications. This behavioral assumption helps us to determine the least-cost input combination for producing a given level of output. In this case,

the production technology is characterized by inputs, output, and input prices. So now the question arises what should be the best that the producer can do to minimize the cost of producing a given level of output and the answer provides standard against which the economic performance of producers can be estimated. If firm minimize cost subject to the production function to produce a specific level of output, the first-order conditions of cost minimization state that the slope of the Iso-quant (Marginal rate of technical substitution) should be equal to the ratio of input prices, (Kumbhakar et al., 2015).

$$MP_K/MP_L=P_K/P_L = r/w$$

Where MP_K is Marginal Productivity of Capital, MP_L is Marginal Productivity of Labour, P_K is Price of Capital, P_L is Price of Labour, r is Rent and w is Wage.

If a firm fails to use inputs according to the above rule, then it is said to be allocative inefficient. In this case the cost of producing the same level of output will be higher. It is important to note that not all cost inefficiency is necessary attributed to the technical inefficiency of the producers, but it could be a combination of technical and allocative inefficiency. Input allocative efficiency is measured as Allocative Efficiency (AE) = Cost Efficiency (CE) / Technical Efficiency (TE) and its value is in between zero and one and attains its upper limit if, and only if the input vector can be radially contracted to the cost minimizing input vector. So, decomposition of cost efficiency into input-oriented technical efficiency and input-oriented allocative efficiency. The measurement of cost-efficiency decomposed as CE=TE*AE. Allocative efficiency (AE) measures the farmers' success in selecting the optimum input combination that is the ratio of marginal products for each pair of inputs that equals the ratio of their respective market prices (Farrell, 1957), (Coelli, 1996). Cost efficiency helps in understanding the resource utilization scenario. Sometimes, farms are technically efficient but allocative inefficient. Actually, cost inefficiency is nothing but the result of technical and allocative inefficiency. This work tried to examine the cost efficacy and the variables influencing cost efficacy. Mostly farm size, farmers' experience, age of the farmers' and education level are considered as inefficiency-affecting variables. The determinants of cost inefficiencies in agriculture deal with farm level primary data, mainly the scenario of cost and technical inefficiencies of the farms of different sizes. The objective of this stochastic frontier analysis (SFA) to explain the results whether groundnut farmers with high scores of extensions (age, education, experience, land size etc.) are more cost efficient as compared to low extension activities. Batterse & Colli have used allocative efficiency and technical efficiency with Cobb Douglas production function on panel data (Batterse & Coelli, 1995). The first use of SFA for the estimation of technical efficiency was made by Coelli (Coelli, 1996), and Batterse and Coelli (Batterse & Coelli, 1995) followed by (Varasani, Shiyani, Ardeshna, & Swaminathan, 2016), (Belbase & Grabowski, 1985), (Mathijs & Swinnen, 2001), (Chennareddy, 1967), (Chavas, Petrie, & Roth, 2005), (Tolley & Farmer, 1964), (Cornwell, Schmidt, & Sickles, 1990), (Ali & Flinn, 1989), (Kalirajan, 1981) and many more have used stochastic production function to estimate the technical and allocative efficiency of farmers in producing different crops in different countries.

4. Production Function Equation

This study has used a simple Cobb-Douglas production function for the groundnut producing farm households. Groundnut crop is cultivated during the beginning of the kharif or rainy season (June to October). In this season seeds are sown at the beginning of the monsoon season and the crops are harvested at the end of the monsoon season. This is raining season in India therefore in this period crops depend fully on rainy water system. Kharif season of the groundnut requires: land, Tillage, seeds, Labour, fertilizer and herbicides. Survey shows application of fertilizer as an insignificant variable. Finally land, labour, herbicide, seeds and output of the groundnut were used for production and cost function.

$L_nY=\beta_0+\beta_1L_nX_1+\beta_2L_nX_2+\beta_3L_nX_3+\beta_4L_nX_4+L_nV_i-L_nU_i$……………………………………………..(I)

L_nY= log of output of groundnut in Kg

L_nX_1= log of quantity of seed per acer in Kg

L_nX_2= log of tillage times

L_nX_3= log of labour (in man days) /acre

L_nX_4= log of Herbicide in gram litter /acre

L_nVi= log of random variable in model

L_nUi= log of random variable which are assumed to account for technical inefficiency

Definition of the variables used in stochastic model:

1. L_nY= log of output of groundnut in Kg

This is the per acre yields of groundnut measured in kg.

2. L_nX_1= log of quantity of seed per acre in Kg

Per acre groundnut seeds weight have used in kg.

3. L_nX_2= log of tillage times

4. L_nX_3= log of labour (in man days)/ acre

Man-days of both, Hired and family labour have been taken together. That is the total man hired labour, and family labour days. This is the total labour days per acre during the farm operation with standard 8 hours per day.

5. L_nX_4 = log of amount of Herbicides in litter used for weeds management.

The technical efficiency of groundnut producer for the ith farmer, defined by the ratio of observed production to the corresponding frontier production associated with no technical inefficiency, is expressed by TE=exp ($-U_i$) so that $0\leq TE\leq 1$

Variance parameter are: $\delta^2=\delta^2_v+\delta^2_u$ and $\gamma=\delta^2_u/\delta^2$…………………. ……..(II)

So that $0\leq\gamma\leq 1$.

It is assumed that the technical inefficiency effects are independently distributed and Ui emerged by truncation (at zero) of the normal distribution with mean, μ_{ij} and variance.

4.1. Technical inefficiency Model

$L_nU_{ij}=\delta_0+\delta LnZ_{1ij}+\delta_2\,L_nZ_{2ij}+\delta_3\,Ln\,Z_{3ij}+\delta_4LnZ_{4ij}$……………………..(II)

Where:

L_nU_{ij}= log of Inefficiency effect

L_nZ_1= log of Age of groundnut farmers

L_nZ_2= log of Education level

L_nZ_3= log of Farming Experience

L_nZ_4= log of Land Size

4.2. Stochastic Cost Function

$$L_nC_y=\beta_0+\beta_1L_nP_1+\beta_2L_nP_2+\beta_3L_nP_3+\beta_4L_nP_4+L_nV_i-L_nU_i \quad \text{(III)}$$

Where:

L_nC_y= log of Per Acre total Production cost (in Rupees)

L_nP_1=log of Per Acre seeds cost (in Rupees)

L_nP_2=log of Per Acre tillage cost (in Rupees)

L_nP_3= log of Per Acre cost of Manual Weeding (in Rupees)

L_nP_4= log of Per Acre cost of Chemical weeding (in Rupees)

L_nV and L_nU as already defined above.

4.3. Inefficiency Model

$$L_n\,\mu_y = L_n\delta_0 + \delta_1L_nz_{ij}+ \delta_2L_nz_{ij}+ \delta_3L_nz_{ij}+ \delta_4L_nz_{ij} \quad \text{(IV)}$$

$L_n\,\mu_{ij}$= log of inefficiency of the i^{th} farmer,

$L_n\,Z_1$= log of age of groundnut farmers (in year)

$L_n\,Z_2$= log of education level.

$L_n\,Z_3$= log of farming Experience (in year)

$L_n\,Z_4$= log of land size (in Acre).

5. Results

The results of the maximum likelihood estimates of the stochastic production and cost frontier with ‘t’ statistics for the groundnut crop are presented to show production and cost functions with its inefficiency model. The fact is that, a high level of inefficiency in groundnut cultivation means, a significant part of the variability in the production among farms is explained by the existing difference in the level of technical inefficiencies. These results suggest that the effects of technical inefficiency are significant component of the total variability of groundnut output and its cost. The first step regarding the application of stochastic frontier analysis within the ML specifications using null hypothesis H0: $\beta_1=\beta_2=\beta_3=\beta_4=0$ which was rejected. The second important step is to test significant of

technical inefficiency using null hypothes H0: ϒ, which tests whether the observed variations in efficiency are simpaly random. If value of gamma (ϒ) is close to zero, then differences in the production will be due to statistical noise, while if gamma (ϒ) is close to one, it reveals the presence of technical inefficiency. In the analisys of this work ϒ (0.99), measures, the variability of the two sources of error. It suggests 99% of the total varaintion attributed to the total production was due to inefficient error term and only 1% of the variation is related to stochastic random error. It shows that the variation of the total production among the different groundnut farmers was due to the differences in their inefficiencies.

Table 2: Stochastic Production Function for Weed Management Practiced Groundnut Farm

Variables (ln)	Parameters	Coefficient	t-ratio
Constant	β_0	2.14*	13.7636
Seed Weight	β_1	0.42*	7.1796
Tillage (Times)	β_2	-0.13*	-3.3242
Labour (No.)	β_3	0.05(NS)	0.6485
Herbicides (gram)	β_4	0.64*	11.2449
Inefficiency Model (ln)	Parameters	Coefficient	t-ratio
Constant	δ_0	2.11**	2.5158
Age	δ_1	-0.49***	-1.9634
Education level	δ_2	-0.03***	-1.5898
Farming Experience	δ_3	0.13***	1.557
Land Size	δ_4	-0.14***	-1.7001
Sigma squared	σ^2	0.46*	7.1776
Gamma	ϒ	0.99*	2222913.2

***10%, **5%, *1%, Significance level
Source: Primary survey data 2018/ Sikhar block of Mirzapur District/Uttar Pradesh/India

The result for this function shows that seed weight, tillage and herbicides have the significant value at 1% level of significance respectively. Whereas manual weeding management has insignificant value and Extension variable are also found significant at 1%, 5% and 10% significant level.

Table 3: Stochastic Cost Function for Weed Management Practiced Groundnut Farm

Variables (ln)	Parameters	Coefficient	t-ratio
Constant	β_0	1.35*	128.4
Seed Cost	β_1	0.26*	42.12
Tillage Cost	β_2	0.26*	48.83
Manual Weeding Cost	β_3	0.35*	65.04
Chemical Weeding Cost	β_4	0.11*	16.71
Inefficiency Model (ln)	Parameters	Coefficient	t-ratio
Constant	δ_0	-3.87*	-6.4
Age	δ_1	0.63*	4.82
Education level	δ_2	-0.20*	-7.12
Farming Experience	δ_3	-0.15*	-3.21
Land Size (in biswa)	δ_4	-0.24*	-5.18
Sigma squared	σ^2	0.14*	6.97
Gamma	Υ	0.99*	1316834.6

***10%, **5%, *1%, Significance level
Source: Primary survey data 2018/ Sikhar block of Mirzapur District/Uttar Pradesh/India

In cost Frontier function, all variable are found highly significant to contribute total cost. Extension variables including age, education level, farming experience, and land size are also highly significant at 1% significant level. A research work was conducted in Sudan to know the level of technical efficiency, the major factors responsible for inefficiency, and the improvement level through Gezira scheme for Sudan's groundnut farmers. Farmers' age, family size, farmers' experience, education level, seed sowing date, number of irrigation and total workers were found to be the major factors associated with changes in groundnut productivity. Average technical efficiency was found to be 65% for groundnut producers, which shows that production of groundnut could be improved by 35% at the existing level of inputs, by just improving farmer efficiency (Babiker O. Mahgoub, Sara A.E. Ali, n.d.). This

work shows that the majority of farmers are highly technical inefficient and due to high technical inefficiency and allocative inefficiency mean value of cost efficiency is very low (0.11). Figure-1 & 2 shows the mean value of efficiencies and distribution of value of cost and technical efficiency among farmers.

5.1. Technical, Allocative and Cost Efficiency

Summaries of technical efficiency (TE) and allocative efficiency (AE) scores of the matched samples are presented in figure-1 & 2. The sets of TE are estimated with the help of conventional stochastic frontier analysis. Technical efficiency now ranges from zero to 1, with mean of 47 percent. In this situation, Farm household can gain more of precision by placing more structured model. Average technical efficiency was found 0.47 (47%) followed by 0.23 (23%) allocative efficiency and 0.11 (11%) cost efficiency of groundnut producers, which shows that production of groundnut could be improved by 53% at the existing level of inputs, by reducing technical inefficiency. Farmers' age, education level, seed, herbicides and worker were found major factors associated with technical efficiency of the groundnut farmers. Low value of allocative efficiency shows that there is need of reallocation of resources. Finally improvement in technical efficiency and allocative efficiency will lead to a good cost efficient direction, which will help to enhance the farmers' profit and standard of living.

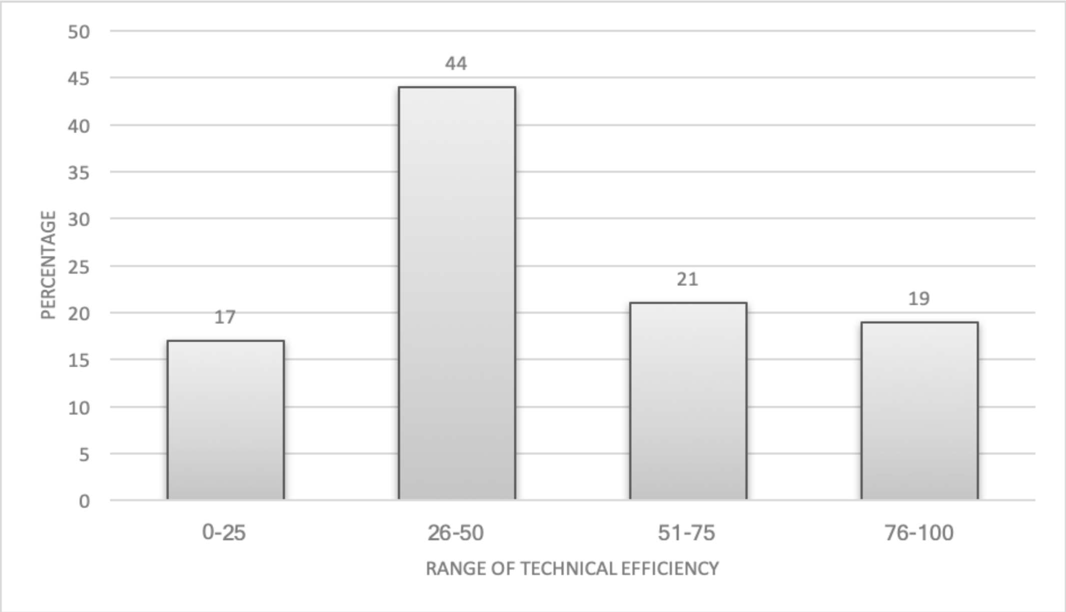

Figure:1 Frequency Distribution of Technical efficiency

Source: Primary survey data 2018/ Sikhar block of Mirzapur District/Uttar Pradesh/India

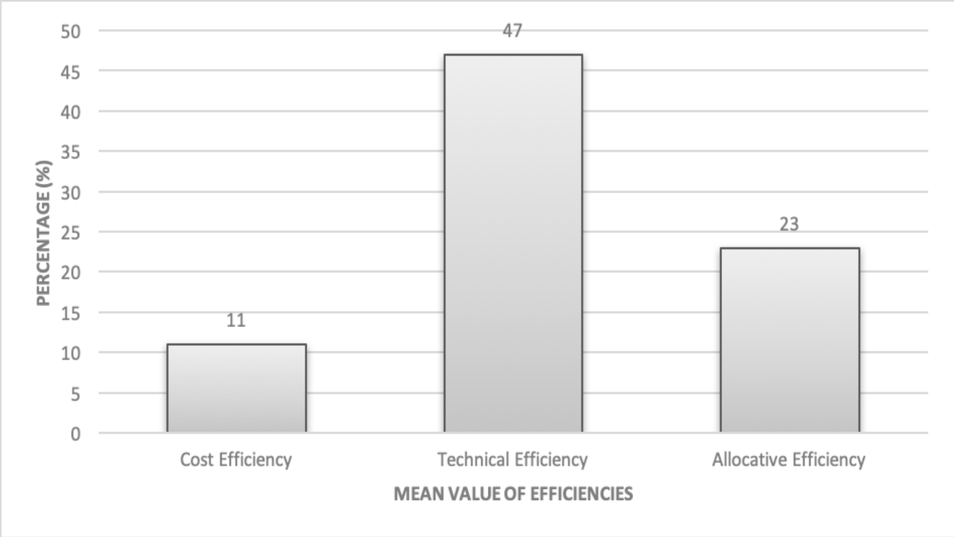

Figure:2 Efficiency Score

Source: Primary survey data 2018/ Sikhar block of Mirzapur District/Uttar Pradesh/India

6. Discussion

Economic efficiency at the micro-level focuses on the ability of firms to utilize the best available technology and to allocate resources productively. It is typically decomposed into their sources: technical, allocative and cost efficiency. Technical efficiency is attained when the best available technology is used. Allocative efficiency holds when resource allocation decisions minimize costs and maximizing profit at a given market price level. Economic scale efficiency means that firms are of the appropriate size so that no industry reorganization will improve output or earnings. This study has presented an economic analysis of technical, allocative and economic efficiency among groundnut farm households of Sikhar block of Mirzapur district in Uttar Pradesh. Results of this work have argued that efficiencies are varying across the different farms due to few efficient variables and efficiency. The coefficients for the technical inefficiency results are interpreted by their signs, such that a positive (negative) coefficient indicates a positive (negative) effect on inefficiency. In simple words, we have only discussed the determinants, focusing on variables that are statistically significant at conventional levels. In the result of the inefficiency model, age, education level, farming experience, land size were found significant at conventional levels and positively related to technical inefficiency (negatively related to technical efficiency). In the stochastic production function, the coefficient of age was negative and significantly different from zero at 10% level, representing that younger farmers were more inefficient compared to aged farmers. The negative and significant sign of the coefficient of the education level and land size also found significant at 10% level, implying that education level and large land size household farmers were more efficient, which is similar to the findings previous works (Ali & Flinn, 1989), (Win et al., 2009), (Ani, D. P., Umeh, J. C., Weye, 2013). The positive and significant sign of the coefficient of the farming experience variable indicates that farmers, who have more experienced in farming, were more inefficient, contrary to our a priori expectation. It could be due to fact that experience holder farmers have been habituated to use convention methods of farming and not ready to adopt new technology. Results of stochastic cost function were almost similar for the major cost inefficient variables but there we found astonished results which should be noted. Actually, coefficient for the technical inefficiency was found to be negative in production function and just opposite negative sign in cost function for cost inefficiency. Negative sign of age for the technical inefficiency reflects that young farmers were more inefficient as compared to aged farmers, but in the stochastic cost function, aged farmers were found more inefficient in comparison to younger formers. This is an important results indicating that the young framers are more efficient in cost efficiency and they have more ability to select a lower price combination of inputs to reduce cost inefficiency. The analysis of this work gives evidence of both technical (where households do not make use of best available techniques) and allocative efficiency (where farm households do not take decisions to minimize cost at given market price) and this efficiency varies among farm households. Frequency distribution of efficiency level is distributed in discriminated form from low to high. In upper limit interval of technical efficiency from 76-100 shows that there is a possibility of improvement in the rest of farm households. The major source of inefficiency is allocative inefficiency, reports a failure to respond to price and resource scarcity in household decision-making. However, the cost of these inefficiencies is 53 percent and 77 percent from technical and allocative inefficiency respectively. We find that significant part of allocation efficiency cost came from age, education level, farming experience and size of land which shows the importance of analysis at household level rather than the farm level. This study suggests that the imperfection in education, age, and farming experience causes to reduce productivity and lower efficiency in the groundnut farm households. It shows that the efficient determinants have the potential source of efficiency and it could be relevant for policy formulation.

7. Limitation of the Work

This study may suffers some limitations. We used a simple empirical model on cross section primary data for this study , there could be apossibility of the omitted variables problem, which may bias the results. We only used the inputs and outputs in this research work but we should alos concider its weaknesses. 205 numbers of the farmers were selected for the interview but other farmres may have other opinion and information. So, we assumed that these farmers are representing information for all farmers in particular area. A block from Mirzapur district was selected for the primary survey, so infomatio may also vary one block to other blocks.

8. Conclusions and Recommendations

This study uses a sample Stochastic Production Frontier Analysis (SFA) model to determine the Technical efficiency (TE) of groundnut farmers through a case study of Sikhar, block of Mirzapur district in Uttar Pradesh. The Technical inefficiency is fairly high, indicating that, access to technology is a severe constraint for most of the farm households. The cost of scale inefficiency including technical and allocative inefficiency is high. The results of this study have argued that efficiencies are varying across the different farms due to some efficient variables i.e. farmers education level, farming experience, age and land size.
Younger farmers were found more inefficient as compared to aged farmers and on education level, farmers with large land size were found more efficient. The significant value of the coefficient of the farming experience indicates that farmers, who have more experience in farming, were more inefficient, contrary to our a priori expectation. This is surprising result. It could be due to fact that the experienced farmers have been habituated to use convention methods of farming and not ready to adopt new methods. Frequency distribution of efficiency level is distributed in discriminated form from 0-100. In upper limit interval of technical efficiencies 76-100 shows a possibility of improvement in the rest of farm households. The major source of inefficiency is allocative inefficiency, indicating a failure to respond to price and resource scarcity in household decision-making. However, the cost of these inefficiencies is 53 percent and 77 percent from technical and allocative inefficiency respectively. This study shows that the significant part of allocation efficiency cost arises from age, education level, farming experience and size of land and there is need to analyze at household level rather that the farm level. This study suggests that imperfection in education, age, and farming experience kick to reduce productivity and lower efficiency in the groundnut farm

households. It reflects the efficient determinants have the potential source of efficiency and it could be relevant for policy formulation. This study on groundnuts, an important oilseed crop has a bearing on Indian Agriculture scenario as well and would be highly useful in framing agriculture policies especially focusing on allocative efficiency, cost efficiency and Technical efficiency.

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