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TECHNICAL EFFICIENCY AND FARM SIZE PRODUCTIVITY—MICRO LEVEL EVIDENCE FROM JAMMU & KASHMIR

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Abstract

The paper estimates the technical efficiency and the relationship between farm size and productivity efficiency. Field survey data of 461 farmers from district Pulwama of Jammu & Kashmir (India) for the year 2013-14 were used to estimate the technical efficiency by employing Non-parametric Data Envelopment Analysis. Average technical efficiency worked out to be 48%. Most of the farms were operating at low level of technical efficiency. There was also wide dispersion in technical efficiency across farm categories. Farm size and productivity efficiency relationship was found to be non-linear, with efficiency first falling and then rising with size. Large farms tend to have higher net farm income per acre and are technically efficient compared to other small farm size categories. The study further delineated the socio-economic, institutional and farm factors of technical efficiency using Two-limit Tobit Regression Model. The results showed that Occupation, Farm Experience, Household Size, Farm Size, Membership and Seed Type were found to be important determents that influence the discrepancies in technical efficiency across farm sizes. Policymakers should, therefore, foster the development of the socio-economic, institutional and farm specific factors in order to build the capacity and management skills of the farmers.

Keywords: *Farm size, technical efficiency, Data Envelopment Analyses, Tobit Model*

1. Introduction:

Following from (Sen, 1962) number of seminal studies were conducted to test farm size productivity relationship popularly known “Inverse Hypotheses” [(Sen, 1964); (Khusroo, 1964); (Mazumdar, 1965); (Rao, 1966); (Baradwaj, 1974); (Rao, 1975); (Chattopadhyay & Rudra, 1976); (Chada, 1978); (Bhalla, 1979); (Carter, 1984); (Feder, 1985); (Binswanger & Rosenziveig, 1986); (Bhalla & Roy, 1988); (Chattopoyda & Sengupta, 1997); (Fan & Chan-Kang, 2003); (Shanmugam, 2003); (Helfand et al., 2004); (Shanmugam & Venkataramani, 2006); (Hazell, et al., 2007); (Thapa, 2007); (Kumar & Mittal, 2010); (Chand, et al., 2011)]. These studies have richly helped in developing an informed understanding of the underlying issues. For excellent reviews of this debate see (Bhagwati, J N & Chakravarty, S, 1971). Given the insufficiency of evidence on the statistical validity of the supposed inverse relationship and lack of convergence among the results of the numerous studies, there is obviously need for more rigorous analyses to arrive at a comprehensive view of the phenomenon (Bhattacharya & Saini, 1972). Consensus and convergence have, however, proved elusive. This literature can be broadly sub-divided into:

- Studies which conclude that inverse relationship holds (Sen, 1962); (Sen, 1964); (Khusroo, 1964); (Mazumdar, 1965); (Rao, 1966); (Bhalla, 1979); (Binswanger & Rosenziveig, 1986); (Chattopoyda & Sengupta, 1997);
- Studies which infer that with change in technology the Inverse relationship has disappeared (Rao, 1975); (Chattopadhyay & Rudra, 1976); (Chada, 1978); (Bhalla & Roy, 1988); (Thapa, 2007); (Chand, et al., 2011);
- Studies which deduce that the relationship is non-linear and U-shaped, (Helfand & Levine, 2004).

The first subset provides a strong justification for redistributive land reforms. It is emphatically argued that “equity does matter for efficiency in the agricultural sector”. Second set of studies assign centrality to the technological factors and attribute differences in productivity to agro-climatic factors particularly land quality. The advocates of this sub-set find fault with the methodology employed by the supporters of ‘inverse-hypothesis’. They opine that by “calculating total factor productivity it is likely that inverse relationship may be less pronounced or perhaps even reversed”. The last sub-set showed the relationship between farm size and productive efficiency was found U-shaped Rather than an inverse relationship, where productivity falls as farm size rises up to a certain level then it rises again beyond that level. The reasons for broke down the inverse relationship are relate to preferential access by large farms to institutions and services that help lower inefficiency, more intensive use of the technologies and inputs that raise productivity.

Be that as it may, farm size productivity debate has assumed renewed importance in the wake of the changes brought about by liberalization, commercialization, growing cost of the technological changes on human and environmental health and proliferation of tiny landholdings. Focusing on hitherto neglected aspects of agrarian transformation has become highly critical for sustainable policies. Technical efficiency in agriculture affects farm productivity both directly as well as indirectly (see Jha & Rhodes, 1997); (Shanmugam & Venkataramani, 2006). Despite its centrality it has not been accorded enough attention. In view of the transformation of the agrarian sector there is obvious justification to recast the role Technical Efficiency. The problem assumes added significance in view of the share size of the world rural population which, directly or indirectly, depends upon primary sector for employment. Increasing landlessness, growing number of small and marginal holdings, subdivision and parcelization of these holdings have further compounded the problem. Growing land concentration has serious efficacy and equity implications. These are fraught with serious socio-economic implications. High incidences of rural poverty, environmental degradation, ever-increasing rural urban migration and growing regional inequalities are some of the widely documented problems. In the context of over populated agrarian economies like India though resolution of these problems has remained at the centre-stage of the development planning yet success has belied expectations. Indian agriculture, with vast geographical, climatic, economic and regional diversities offers rich scope for such studies. Against this backdrop the present paper attempts to recast the link between technical efficiency and farm productivity.

The paper has been organized into five sections. Following introduction, which prefaces the justification for the present study, Section II depicts an overview of the study area and objectives of the study. Methodology and data sources have been discussed in Section III. In Section IV the results and discussions are presented. The conclusions and policy implications are presented in Section V.

2. Overview of the Study Area and Objectives of the Study

Agricultural transformation and poverty alleviation were regarded as strategic factors in the development process in Jammu and Kashmir right from 1947 (Beg, 1951). State was one of few states of the country where radical land reforms were introduced in early 1950s (Thorner, 1953 & Bhat, 1963). Reforms in land relations, availability of institutional finance, irrigation facilities, input subsidies, non-farm inputs, support prices, better marketing facilities, extension education and substantial public expenditure on agricultural and rural development programmes contributed to the process of transformation and growth (See Goldbloe Committee Report, 1998). Consequently production conditions in the state witnessed a number of positive changes (Bhatt, M. S. & Alam, S. N., 1987). Along with increase in the productivity of major food crops the state has seen the emergence of exceptionally low asset inequalities (Bhatt, 1993). The area under foodgrain crops has increased by 2.61% from 992 thousand hectares in 2001-02 to 1018 thousand hectares in 2010-11 which accounted for 89.5% of the total cropped area in 2010-11. The major gainers in the increase in area have been fruits and vegetables, fodder, wheat, maize and oilseeds. Total foodgrain production has increased by 213.0% during 1950-51 to 2001-02 and from 87.77% from 2001-02 to 2010-11. Rice, wheat and maize constitute 97.37% of the output in 2010-11, compared to 86.38% in 1950-51. While the share of rice in the total foodgrains production has declined from 53.62% in 1950-51 to 33.36%in 2010-11. The share of wheat and maize has increased from 9.5% and 23.18% in 1950-51 to 25.68% and 40.28% in 2010-11, respectively. Productivity of total food grains has increased by 67.56% that is from 8.14 quintals per hectare in 1951-52 to 14.94 quintals per hectare in 2010-11, with a peak productivity of 17.65 quintals per hectare in 1980-81. Cropping intensity has increased from 111.13 in 1951-52 to 151.87 in 2010-11. Similarly, percentage area irrigated in the net area sown works out to be 41.96% in 1950-51 and 43.80% in 2010-11.Compared to the rest of the country land distribution is less skewed in Jammu and Kashmir. Informed studies have attributed this to the agrarian reforms introduced from 1950 to 1976 (see Bhatt, 1993). Along with the impressive gains the failures have equally been disquieting. Higher output for example has not reduced the state's dependence on food purchases from outside the state. Demographic pressure and growing scarcity of arable land have diluted the gains. Growing marginalization of agricultural holdings has constrained the scope for scaling up the yield. Lack of appropriate farm technology has further compounded this problem. Experts opine that marginal and small holdings have become non-viable (Bhatt, 1993), (Nair, 1990). Agricultural holdings in the state are mostly parceled at several places all over the village and sometimes even beyond village boundaries. Parcelization is also a serious constraint to higher yield (Bhatt, 1993). Consolidation of holdings was designed to arrest and reverse the growing trend of parcelization. Except some experimental work nothing substantial has happened on this front. About 94% of the holdings fall in the size class of less than 2 hectares and around 81.5% in less than 1 hectare. According to the State's Economic Survey for 2011-2011 the average size of operational holding was below national average (0.56 hectare compared to 1.16 hectares at the national level).

This high degree of proliferation of marginal/tiny holdings, accompanied by parcelization, is indeed a disturbing phenomenon of far reaching consequences. Of late new challenges are surfacing. Lot of arable land is getting converted into non-agricultural uses such as housing, physical infrastructure etc. Agricultural transformation has also adversely impacted environment. Very little has been done even to understand its ramifications. Among other things there is need for analytical micro level studies to capture context specific problems and prospects of agricultural transformation. It is important to know how efficiently improved technologies are being used by various categories of farmers (Jha & Rhodes, 1997). Received literature shows variations in efficiency across the regions. The determinants of this variation are crucial for identifying appropriate strategies to improve efficiency. Against this background the present study attempts to analyse the interface between technical efficiency and farm size productivity with special reference to the district Pulwama of the India State of Jammu and Kashmir. The main crops cultivated in the district include Paddy, Maize, Mustard and Pulses. The yield per hectare is the 2nd highest in the state which is 2.62 tonne per hectares (Gupta et al., 2009). The world famous saffron fields adorn the district and the cherished Fruits (apple, pear) make an important contribution. By the last decade various information and communication technologies were used in imparting the trainings to the farmers. These trainings consisting of technical aspects, including agronomic practices, pest and disease management etc., were imparted to the farmers by various means of communication/media and to assess which method of communication was more effective in imparting the technology (Kumar et al., 2013).The specific objectives of the present study are to:

- Study the relationship between farm size productivity and technical efficiency of farming sector in the study area;
- Identify the specific factors that affect the technical efficiency of farmers in the study area;
- Propose Policy prescriptions for increasing farm productivity.

3. Data Sources and Methodology:

The study is based on the primary data collected through a field survey conducted during the Year 2013-14. Four hundred sixty one respondents from two blocks viz (Pulwama and Kakapora) were selected through stratified random sampling. The district Pulwama was purposively selected; because the yield of food crops per hectare is the 2nd highest in the state and almost all the major food and non-food crops are grown. In the district livestock forms an integral part of the farm economy and horticulture contributes 12.38% to the total production of fruits of the state (NHB, 2008). Pulwama and Kakapora blocks were selected as they ranked the highest in agriculture production in the district (Malik & Hussain, 2012). Ten villages were randomly selected from each block and then 20-22 farm households were selected from each village. The computer program DEAP version 2.1 was used to calculate the efficiency scores. For the DEA analysis, we use aggregate agricultural output and six inputs like Area Utilized, Labour, Fertilizers, Chemical Spray, Seeds and Intensity of Irrigation. STATA version 12 software was used to find out the determinants of technical efficiency by employing Two-limit Tobit Regression Model.

3.1 Specification of the Model, Methods and Variables

Measurement of productivity efficiency enables us to quantify the potential increase in output that might be associated with an increase in efficiency (Farrell, 1957). We employed Input-Oriented Data Envelopment Model (DEA) to estimate efficiency. Both Parametric and non-parametric techniques are employed to estimate efficiency. There are three major Parametric Approaches: Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA). Among the Non-Parametric Approaches Data Envelopment Analysis (DEA) is widely used. It was first developed by Charnes et al., (1978) and is known as CCR Model (Farrel, 1957). According to (Coelli, Rao & Battese, 1998), the constant returns to scale (CRS) DEA model is only appropriate when the farm is operating at an optimal scale. Some factors such as imperfect competition, financial constraints, etc. may not allow a farm to operate optimally. To capture this possibility, (Banker, Charnes & Cooper, 1984) introduced the Variable Returns to Scale (VRS) DEA model. This version is popularly known as BCC Model. Between an input-oriented and output-oriented DEA model (Coelli, et al., 2002) suggests that manager of a farm should prefer one which ensures control over the quantities (inputs and outputs). As farmers have more control over inputs than output we employ input-orientated DEA model. It provides greater flexibility since it does not require a priori assumption on the functional relationship of inputs and outputs. However, it does not provide a mechanism for improving the performance of the best practice units that form the frontier. Therefore, for efficient farm households/decision making units (DMUs), no further improvement can be considered based on DEA results. The present study estimates the overall agricultural productivity efficiency into technical efficiency, pure technical efficiency and scale efficiency. However, the technical efficiency is the major criteria for measuring efficiency in agriculture because technically efficient farmer is one who produces the maximum output for a given amount of inputs, conditional on the production technology available.

3.2 Technical Efficiency Under Constant Returns to Scale

DEA measuring the technical efficiency of a given individual by calculating an efficiency ratio equal to a weighted sum of outputs over a weighted sum of inputs. For each DMU these weights are derived by solving an optimization problem which involves the maximization of the efficiency ratio for that DMU subject to the constraint that the equivalent ratios for every unit in the set is less than or equal to 1. Efficiency rate defined in this way takes the values from 0 to 1. Optimal weights are obtained by solving the following mathematical programming problem:

$$\text{Max } h_0 = \left[\frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \right] \qquad (1)$$

Subject to the constraints:

$$\frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{r=1}^{m} v_i x_{i0}} \leq 1$$

$$(j = 1, 2 \ldots n) \qquad u_r \geq 0, v_i \geq 0$$

$$\text{For } (r = 1, 2, 3 \ldots s); \ (i = 1, 2, 3 \ldots m)$$

Where h_0 is the ratio of outputs to inputs, the u_r and the v_i are the weights to be determined by the output r and input i respectively and the y_{r0} and the x_{i0} are the observed output and input values of the *DMU* to be evaluated. The objective is to a obtain weight (u_r,v_i) that maximises the efficiency ratio of *DMU*. This problem cannot be solved as stated because the difficulties associated with non-linear (fractional) mathematical programming representing infinite number of solutions. (Charnes, et al., 1978) solved this problem by introducing a new constraint $\sum_{i=1}^{m} v_i x_{i0} = 1$. This formation converts the above nonlinear programming problem into a linear one. In this model, the denominator has been set equal to 1 and the numerator is being maximised. By introducing this constraint, the input-oriented CCR primal Model (M1) can be written as:

$$\text{Max } h_0 = \sum_{r=1}^{s} u_r y_{i0} \qquad (2)$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r \, \mathrm{y_{rj}} - \sum_{i=1}^{m} v_i \, \mathrm{x_{ij}} \leq 0 \;\; (\mathrm{j} = 1 \; \ldots\mathrm{n})$$
$$u_r \geq \varepsilon \; (r = 1\ldots s), \qquad v_i \geq \varepsilon \; (i = 1 \; \ldots m.)$$

Variables defined in M1 are the same as those defined in equation (1). An arbitrarily small positive number, ε is introduced in M1 to ensure that all the known inputs and outputs have positive weight values. In general more the restrictions to the linear programming problem, more difficult it is to solve the problem. For any linear program, by using the same data, the dual problem of the linear program can be built. Solution under dual program reduces the number of restrictions of the DEA model. That is why in the empirical analyses the dual program of the DEA model is preferred. This model is able to identify any apparent slack in inputs used or output produced. It further provides insights on the possibilities for increasing output and/or conserving input in order to help an inefficient decision making unit to become efficient. The dual program of the linear programming M1 is named as Model (M2) and is written as:

$$\mathrm{Min}\,\mathrm{h}_0 = \theta_0 - \varepsilon\left[\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right] \tag{3}$$

Subject to:

$$\sum_{i=1}^{m} x_{ij}\lambda_j + s_i^- = \theta_0 x_{i0} (\, i = 1\ldots\ldots, m \,)$$
$$\sum_{r=1}^{s} y_{rj}\lambda_j - s_r^+ = y_{r0} (\, r = 1\ldots\ldots, s \,)$$
$$\lambda_j \geq 0 \quad (j= 1\ldots\ldots, n), \qquad s_i^- \geq 0, \;\; s_r^+ \geq 0$$

In the above Equation, θ_0 denotes the efficiency of DMU_0 while y_{rj} is the amount of *rth* outputs produced by DMU_0 using x_{ij} amount of *ith* input. Both y_{rj} and x_{ij} are exogenous variables and λ_j represents the benchmarks for a specific DMU under evaluation (Zhu, 2003). Slack variables are represented by s_i and s_r.

3.3 Technical Efficiency Under Variable returns to Scale

To identifying that whether a farm (DMU) is operating in increasing, decreasing or constant returns to scale we followed (Coelli et al., 1998) and used BCC Model. CRS linear programming problem can be easily modified to account for Variable Returns to Scale by adding the convexity constraint $\sum_{j=1}^{n} \lambda_j = 1$ to M2. The BCC model can be written as:

$$\mathrm{Min}\,\mathrm{h}_0 = \theta_0 - \varepsilon\left[\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right] \tag{4}$$

Subject to:

$$\sum_{i=1}^{m} x_{ij}\lambda_j + s_i^- = \theta_0 x_{i0} (\, i = 1\ldots\ldots, m \,)$$
$$\sum_{r=1}^{s} y_{rj}\lambda_j - s_r^+ = y_{r0} (\, r = 1\ldots\ldots, s \,)$$
$$\sum \lambda_J \geq 1, \quad (j = 1\ldots\ldots n), \quad s_i^- \geq 0, \;\; s_r^+ \geq 0$$

3.4 Scale Efficiency

It is interesting to investigate whether inefficiency in a DMU is caused by inefficient operation of the DMU itself or by the disadvantageous conditions under which the DMU is operating. To answer this question we compared the estimated results of technical and pure technical efficiency scores. Fully efficient DMU in each scenario indicates that it is operating in the Most Productive Scale Size (MPSS) (Banker et al., 1984). If all DMUs are not operating at the optimal scale use of the CRS specification will result into measures of technical efficiency which are confounded by scale efficiencies (SE). Use of VRS specification will permit the calculation of the TE devoid of these SE effects. $TE_{CRS} = PTE_{VRS} * SE$ *where* TE_{CRS} = Technical efficiency of constant returns to scale, PTE_{VRS} = Technical efficiency of variable returns to scale, *SE* = Scale of efficiency, $SE = TE_{CRS} / PTE_{VRS}$, Where $0 \leq SE \leq 1$ since $TE_{CRS} \leq PTE_{VRS}$.

If the value of SE equals 1 the firm is scale efficient and all values less than 1 reflect scale inefficiency. If scale inefficiency exists *(SE < 1)* the source of inefficiency is the result of operating at either increasing *(NI < VR)* or decreasing *(NI = VR)* returns to scale. The existence of IRS or DRS can be identified by the sum of intensity variables (i.e. $\sum_{j=1}^{n} \lambda_j = 1$) in the CCR model. If $\sum_{j=1}^{n} \lambda_j < 1$ then scale inefficiency appears due to increasing returns-to-scale. The implication of this is that the particular farmer has sub-optimal scale size. On the other hand, if $\sum_{j=1}^{n} \lambda_j > 1$ then scale inefficiency occurs due to decreasing returns-to-scale.

3.5 Efficiency Improvement Slacks and Targets

For getting the more focused diagnostic information about the sources of inefficiency for each farmer with respect to the input and output variables, the target values of these variables (xˆ, yˆ) at farm level using technical efficiency scores at constant returns to scale are defined by the following formulae:

$$X_{i0} = \theta_i^* x_{i0} - s_i^{-*}$$
$$Y_{r0} = y_{r0} + s_r^{+*},$$

Where X_{i0} =the target input i for 0th farmer, Y_{r0} = target output r for 0th farmer; x_{i0} = actual input i for 0th farmer; y_{r0} =actual output r for 0th farmer; θ_i^*= OTE score of 0th farmer; s_i^{-*} =optimal input slacks; and s_r^{+*} =optimal output slacks. The difference between the observed value and target value of inputs (i.e., $\Delta x_{i0}=X_{i0} - x_{i0}$) represents the quantity of input i to be reduced, while the difference between the target values and observed values of outputs ($\Delta y_{r0}=Y_{r0}-y_{r0}$) represents the amount of output r to be increased, to move the inefficient farmer onto the efficient frontier. Finally, the potential input reduction for input i and potential output addition for output r can be obtained by $(\Delta x_{i0}/x_{i0}) \times 100$ and $((\Delta y_{r0}/y_{r0}) \times 100$, respectively. (Coelli et al., 2002) clearly pointed out that both the Farrell measure of technical efficiency and any non-zero input and output slacks should provide an accurate indication of technical efficiency of a farmer in a DEA analysis. These efficiency targets show how inputs can be decreased and outputs increased to make the *DMU* under evaluation efficient.

3.6 Identifying Factors of Inefficiency

In order to identify the determinants of farm Technical Efficiency the *Two-limit Tobit Regression Model* was used. It is pertinent to prefer this model in cases where the dependent variable is constrained in some way (Long, 1997). Since in the present study dependent variable (technical efficiency) is a censored variable with the lower limit 0 and upper limits 1. Therefore we concurred with Long (1997). Among others this method has also been employed by (Bravo-Ureta et al., 2007); (Featherstone et al., 1997); (Nayagaka et al., 2010). An alternative to Tobit Two-limit Model could be Ordinary Least Square (OLS) estimation will give inconsistent, inefficient and biased estimates because it underestimates the true effect of the parameters by reducing the slope (Gujarati, 2003). Therefore, the alternative approach is using the Maximum Likelihood Estimation which can yield the consistent estimates for unknown parameters. Following from (Amemiya, 1981) the empirical Tobit Model was estimated as follows:

$$y_i^* = \beta_0 + \sum \beta_m X_{jm} + \varepsilon_i$$

Where y_i* = latent variable representing the efficiency scores of farm j is a vector of unknown parameters, Xjm is vector of explanatory variables m (m = 1, 2... k) for farm j and ε_i = an error term that is independently and normally distributed with mean zero and common variance σ^2. Denoting yi as the observed variables,

$$\left.\begin{array}{ll} y_i = 0 & if y_i^* \leq 0 \\ y_i = y_i^* & if\, 0 < y_i^* < 1 \\ y_i = 1 & if y_i^* \geq 1 \end{array}\right\} \rightarrow \qquad (5)$$

Following (Maddala, 1999), the Likelihood Function of this model is estimated by:

$$L(\beta, \sigma / y_i, x_i, L_{1i}, L_{2i}) = \prod_{yi=L1i} \Phi\left(\frac{L_{1i} - \beta' x_i}{\sigma}\right) \prod_{y_i = y_i^*} \frac{1}{\sigma} \phi\left(\frac{y_i - x_i' \beta}{\sigma}\right) \prod_{y_i = L_{2i}} \left[\frac{1 - \Phi(L_{2i} - \beta' x_i}{\sigma}\right] \rightarrow \quad 6)$$

Where L_{1j} = 0 (lower limit) and L_{2j} = 1 (upper limit) where Φ (.) and φ (.) are normal standard cumulative and density functions. In practice, since the log function is monotonically increasing function, it is simpler to work with log of Likelihood function rather than Likelihood function and the maximum values of these two functions are the same (Greene, 2003). The reduced farm of the Tobit Regression Model can be written as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12+} U_i \qquad (7)$$

Y is the dependant variable (Technical Efficiency Score ranges between 0 to 1). The proposed determinants of technical efficiency include: X_1=Age of the farmer (years); X_2=Education (years of schooling); X_3=Farming Experience (years); X_4= Experience Square; X_5=Main occupation (1= if farming and 0 = otherwise); X_6=Household size (number family member's); X_7= Membership of agricultural club/organisation (1 = if yes and 0 = if no); X_8=Farm size (Acres); X_9=Farm size square; X_{10}= Household Assets Owned (value in 000 rupees); X_{11}= Seed Type (1 = improved seed verities and 0=otherwise): Improved seeds mean High quality/highbred seeds provided by ministry of agriculture or any other private agencies. *Otherwise* means domestic seeds; X_{12}= Distance to farm land (kms); U_i is the error term.

Table 1. Descriptive Statistics

Variable	Unit	Small farmers N= 136			Medium Farmers = 191			Large farmers N=134		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Farm income	Rupees* per acre	48400	1757000	481856.04	100750	3521000	642269.74	187250	3918000	885319.59
Cultivated Area	Acres	1	3	2.18	3	5	3.90	5	27	7.86
Family Labour	Per Acre	20	275	83.95	12	215	67.42	4	116	53.99
Hired Labour	Per Acre	0	295	75.30	15	250	92.01	30	350	118.58
No. of labour days	Per Acre	60	525	202.28	51	401	161.86	35	395	146.79
Improved Seed	Per Acre	5	83	40.69	5	81	48.07	3	86	44.92
Fertilizer quantity	Per Acre	1	335	50.94	1	250	47.11	1	335	59.70
Chemical Quantity	Per Acre	0	3	0.93	0	5	1.50	1	11	2.37
Irrigated Area	Acres	3	51	19.16	3	86	22.35	5	76	25.35

Source: Field survey data
Note: *=1 USD=61.46 Rupees or 1 Rupees= 0.01627USD on 10/07/2014

4. Results and Discussions

4.1 Descriptive Statistics

The descriptive statistics of sample farmers' annual output and pattern of inputs used are shown in Table No.1. The output was aggregated into a single variable to avoid the complications in modelling. It is the monetary equivalent of eight major crops (rice, wheat, maize, oilseeds, almond, apple, saffron, and pulses) evaluated at current market price. The Table No.1 indicates that the agricultural inputs used vary across different farm sizes (small, medium and large). The labour input expressed as total number of labour days, includes family labour and hired labour per year. The average farm income for small farmers was (Rs.481856.04) per acre and for medium farmers' it was (Rs.642269.74) and (Rs.885319.59) per acre for the large farmers'. The average farm income increases with increase in farm size. The labour input employed by small farmers was higher than the both medium and large farmers. The relative share of family labours in case of small farmer's turned out to be higher as compared to large farmers as well as medium farmers. However, the quantity of fertilizers used by large farmers was a little higher (597 kgs per acre) compared to the small and medium farmers (509 kgs per acre) and (471 kgs per acre) respectively. The difference in the relative shares of other inputs across farm sizes shows that large farmers employed more inputs than other two categories of farmers.

Table 2 presents the frequency distribution of all the variables. Age has been categorised into two groups (Working population up to 60 years and dependants and above 60 years of age). The difference in the level of formal education across farm sizes shows that large farmers are more educated as compared to both small and medium farmers. It is being argued that adding years of schooling not only improves the efficiency of farmers but also enhanced their capability to understand and adopt new methods and techniques of farming (see for example Olagunju & Adeyemo, 2007). Forty percentof small, 43% of medium farmers and 48% large farmers and had 21-30 years of farming experience. More than 80% of small farmers and 77.44% of medium farmers had farming as main occupation and only 19.9% of small farmers have main occupation as O***ther*** (Govt. employee, business, shopkeeper, and private employee, any other). Corresponding percentages for medium and large farmers were 22.5 and 30.1 respectively. About 17% small farmers, more than twenty five percent of medium farmers and 36.6% of large farmers were having membership of a farming group/organisation indicates that membership increases with increase in farm size. A substantial number of respondents had large family sizes (37.3% large and 15.7% medium and 16.9% small households had more than 10 family members). The value of household assets increases from small, medium and large size farmers. Eighty three percent of Small farmers had household asset valuing less than 5 lakh and only 16.9% had household assets valuing above 5 lakh which is less as compared to both of the medium and large farmers (30.4% and 48.5%) respectively. Only 23.9% large farmers, 40.3% medium and 45.6% Small farmers had farms within one km.

4.2 Efficiency Estimates through Data Envelopment Analysis (DEA)

In order to determine the causes of inefficiency we estimated technical efficiency (CRS), pure technical efficiency (VRS) and scale efficiency. A farmer having technical efficiency score between 0.90>1 is treated as efficient farmer. The estimated results (shown in Table No.3) suggest that scale rather than *technical efficiency* is the major source of overall inefficiency. *Mean scale Efficiency* was lower (0.53) relatively to the *Pure technical efficiency* (0.89). Inefficiencies were mainly due to excessive use of low/inferior quality of inputs and lack of technology. The mean technical efficiency worked out as 0.48 which

Table 2. Descriptive Statistics of the Variables used in Tobit Regression Model

Variables	Unit	Small Farmers (136)		Medium Farmers (191)		Large farmers (134)	
		Frequency	%	Frequency	%	Frequency	%
Education	No Education	46	33.8	69	36.1	29	21.6
	Middle	33	24.3	25	13.1	30	22.6
	Higher Secondary	46	33.8	79	41.4	57	42.3
	Graduate	10	7.4	14	7.3	10	7.5
	Post Graduate and Above	1	0.7	4	2.1	8	6.0
Farm Experience	Exp.<= 10 Years	6	4.4	7	3.7	2	1.5
	Exp. 11-20 Years	40	29.4	44	23.0	28	20.9
	Exp. 21-30 years	55	40.4	83	43.5	65	48.5
	Exp. 31-40 Years	28	20.6	38	19.9	30	22.4
	Exp.41 and above	7	5.1	19	9.9	9	6.7
Occupation	Farming	109	80.1	148	77.5	94	69.9
	Others	27	19.9	43	22.5	40	30.1
Membership of Farm Group	Yes	23	16.9	48	25.1	49	36.6
	No	113	83.1	143	74.9	85	63.4
Age	Up to 60	91	66.9	126	66.0	76	56.7
	Age above 60	45	33.1	65	34.0	58	43.3
Household Size	Up to 10	113	83.1	161	84.3	84	62.7
	Above 10	23	16.9	30	15.7	50	37.3
Household Assets	Upto 500000	113	83.1	133	69.6	69	51.5
	500000 above	23	16.9	58	30.4	65	48.5
Distance from Home	1 km	62	45.6	77	40.3	32	23.9
	Above 1km	74	54.4	114	59.7	102	76.1

Source: Field survey data

implies that, on an average, the respondents were able to obtain around 48% of potential output from a given mix of inputs. This also implies that around 52% of production, on an average, is foregone due to technical inefficiency. In other words, the shortfall of the observed output from the frontier output primarily reflected the inefficient use of the factors that were within the control of the farmers. The technical efficiency levels of the farms ranged from 0.04 to 1. This implies that there is a potential to increase farm output by 52% from the existing level of inputs. The efficiency level varies across different farm sizes for small, medium and large farmers it ranges between 0.13 to 1.00, 0.11 to 1.00 and 0.12 to 1.00 respectively. The mean technical efficiency worked out to be higher for small farmers (0.60) as compared to medium (0.38) and large farmers' (0.48). Twenty three percent of small farmers' were technically efficient (0.90>1). The percentage of technically efficient farmers' decreases to (6.3%) for medium size farmers' and it again increases to (26.9%) for large size farmers'. The results explain that technical efficiency first decreases from small farmers (23%) to medium farmers' (6.3%) and then increases (26.9%) for large farmers'. Overall 17.8% farmers' were technically efficient.

Table 3. Percentage Distribution of the Respondents by Technical Efficiency Estimates

	Small Farmers		Medium Farmers		Large Farmers		All Farmers	
	Frequency	%age	Frequency	%age	Frequency	%age	Frequency	%age
0.10<0.30	16	11.8	77	40.3	9	6.7	138	29.9
0.30<0.60	51	37.5	95	49.7	45	33.6	194	42.1
0.60<0.90	38	27.7	7	3.7	44	32.8	47	10.2
0.90<1	31	23.0	12	6.3	36	26.9	82	17.8
Total	136	100.0	191	100.0	134	100.0	461	100.0
Minimum	0.13		0.04		0.11		0.04	
Maximum	1.00		1.00		1.00		1.00	
Mean	0.6050		0.3862		0.4911		0.4813	
Std. Deviation	0.23993		0.19632		0.27714		0.25165	

Source: Field survey data

The technical efficiency has been used to account for variable return to scale (VRS) to analyse the pure technical efficiency reported in Table No.4. The mean efficiency score for small, medium and large farms turned out to be 94%, 86.6% and 89.4% respectively. The technical efficiency under variable returns to scale for small, medium and large farmers ranged between 0.50 to 1.00, 0.60 to 1.00 and 0.44 to 1.00 respectively. The overall technical efficiency under variable returns to scale varied between 0.44 to 1.00. The estimated results explain that under pure technical efficiency there was an increase in the level of technical efficiency of farming households. The estimated results indicate that the farmers were not operating at optimal scale. There is large scope for reducing the cost of inputs or maximising the output on the same level of inputs. Overall 84.6% farmers' were technically efficient under variable returns to scale.

Table 4. Percentage Distribution of the Respondents by Pure Tech Efficiency Estimates

	Small Farmers		Medium farmers		Large farmers		All farmers	
	Frequency	%age	Frequency	%age	Frequency	%age	Frequency	%age
0.10<0.30	0	0	0	0	0	0	0	0
0.30<0.60	5	3.7	5	2.6	8	6.0	18	3.9
0.60<0.90	12	8.8	25	13.1	16	11.9	53	11.5
0.90<1	119	87.5	161	84.3	110	82.1	390	84.6
Total	136	100.0	191	100.0	134	100.0	461	100.0
Minimum	0.50		0.60		0.44		0.44	
Maximum	1.00		1.00		1.00		1.00	
Mean	0.9406		0.8666		0.8870		0.8944	
Std. Deviation	0.12572		0.11725		0.14403		0.13146	

Source: Field survey data

4.3 Scale Efficiency

Scale efficiency allows us to gain insights into the main sources of inefficiencies. The value of *Scale Efficiency (SE)* equal to 1 implies that the farming household is operating at the *Most Productive Scale Size (MPSS)* which corresponds to constant returns to scale. At MPSS, the farming household operates at minimum point of its long-run average cost curve. Further, *SE<1* indicates that the farming household is experiencing overall *Technical Inefficiency* (TIE) because it is not operating at its optimal scale size. In general, an increase in farm size leads to increase marginal returns and lower the marginal cost. However, beyond a certain size, marginal returns will decrease and marginal cost will increase (but not necessarily simultaneously). Optimal size is reached when marginal returns equal marginal costs. Thus Scale efficiencies are usually a consequence of the better and more efficient use of production factors.

An assessment of Table No.5 reveals that mean *SE* for small, medium and large farms were 64%, 44% and 55% respectively. Their scale efficiency was low relatively as compared to the technical efficiency under variable returns to scale. At the aggregate level the mean scale efficiency worked out to be 53.4% which was also relatively low compared to technical efficiency measured under variable returns to scale. The estimated results show that *SE* scores ranged from a minimum of 0.06 to maximum of 1 at aggregate level. Small farm *scale efficiency* varied between 0.13 and 1. For medium and large farms it ranged between 0.06 to 1.00 and 0.13 to 1.00 respectively. It implies that the average level of *Scale Inefficiencies (SIE)* in the farming sector in the study area were to the tune of about 47%. The percentage of scale efficient farmers varies across different farm sizes it first decreases from 35.3 for small farmers to 7.3 for medium farm sizes and then increases to 33.6% for large farmers. Only 18.7% of farmers attained *SE* score equal to 1 and were, thus, operating at *MPSS*. About seventy eight percent of farms were operating with increasing returns to scale and 3.5% farmers operated under decreasing returns to scale (see Table No.6). On the basis of these results we can safely surmise that for the state as whole scale inefficiency is a serious issue. It also connotes that the farmers have *supra-optimal scale size*. The issue, therefore, need to be investigate across the agro-climatic regions of the state so that appropriate policy responses could be put in place.

Table 5. Percentage Distribution of the Respondents by Scale Efficiency Estimates

	Small Farmers		Medium farmers		Large farmers		All farmers	
	Frequency	%age	Frequency	%age	Frequency	%age	Frequency	%age
0.10<0.30	12	8.8	42	22.0	33	24.6	87	18.9
0.30<0.60	46	33.8	116	60.7	49	36.6	211	45.8
0.60<0.90	30	22.1	19	9.9	7	5.2	56	12.1
0.90<1	48	35.3	14	7.3	45	33.6	107	23.2
Total	136	100.0	191	100.0	134	100.0	461	100.0
Minimum	0.13		0.06		0.13		0.06	
Maximum	1.00		1.00		1.00		1.00	
Mean	0.6437		0.4427		0.5532		0.5341	
Std. Deviation	0.23448		0.19671		0.28929		0.25188	

Source: Field survey data

Number of farming households operating under CRS, IRS and DRS worked out to be 18.7%, 77.8% and 3.5% respectively (see Table No.6). The table suggests that most of the farms were in the early expansionary stage and hence lot of scope was there to improve the efficiency through proper reallocation of the resource use. Out of total number of farmers only 87 (18.7%) farmers were operating efficiently under both CRS and VRS (working under MPSS). Fifteen farmers were operating under decreasing returns to scale (3.5%) and rest (77.8%) farmers were operating under increasing returns to scale. Turning to the scale efficiency, more farms worked below the optimal scale. Across farm sizes, it showed that the high percentage share of scale efficient farms were in the group of large farmers. More than

20% large farmers were operating at MPSS while only 7.4% small farmers operating on MPSS. Majority of farmers operated below the optimal scale approximately 86.8% of small farmers, 71.7% of medium farmers and 67.2% of large farmers were operating under increasing returns to scale. It means that their productivity could increase further. Theses farmers thus need to increase the inputs to achieve optimal scale even if the quality of inputs is treated as given. More than 7% small farmers, 15.2% of medium farmers and 20.1% large farmers were operating under decreasing returns to scale, implying thereby that their productivity could increase by smaller proportion. Thus, downsizing seems to be an appropriate strategic option for these farmers. To reduce unit costs they should reallocate over-utilized resources to other activities where these can be fully utilized. On the whole, increasing returns-to-scale was observed to be the predominant form of scale inefficiency. Thus there is large scope for technological/factor endowment to increase the efficiency in farming sector in study area.

Table 6. Comparison of the Number and percentage of Farmers with Various Returns to Scale.

Category	Small Farmers		Medium Farmers		Large Farmers		All Farmers	
Scale Efficient Farms	Frequency	%age	Frequency	%age	Frequency	%age	Frequency	%age
Constant	10	7.4	29	15.2	27	20.1	87	18.7
Decreasing	8	5.8	25	13.1	17	12.7	15	3.5
Increasing	118	86.8	137	71.7	90	67.2	359	77.8
Total	136	100.0	191	100.0	134	100.0	461	100.0

Source: Field survey data

To assess the directions for improvement in the operations of inefficient farmers the slacks and targets were calculated and are presented in Table No.7. The table presents the target values of inputs and outputs for inefficient farmers along with potential addition in outputs and potential reduction in inputs. The potential improvement shows those areas of improvement in input-output activity which will put inefficient farmers onto the efficient frontier. The results indicated that on an average, 14.01% of Chemical pesticides, 17.37% of intensity of irrigation, 21.70% of improved seeds could be theoretically increased. On the other hand approximately fourteen percent Labour and 17% of Fertilizers could be reduced if all the inefficient farmers operate at the same level as the efficient farmers. Output slack specifies that on average, inefficient farmers could have increased their output by 0.61% by using the same inputs. The estimated results revealed that on an average output worth Rs.4185.95 per acre could have been increased with the same level of inputs. The result further indicated that the inefficient farmers had decreasing returns to scale in two inputs viz labour and fertilizer. It suggests that these farmers could reduce the level of labour by 13.48% (14.56 man days per acre) and fertilizer by 17% (365.62 kgs of fertilizers per acre) in order to reach towards efficient frontier. The analysis further indicated that efficiency level increased with increase in land size after 5.3 acres. Inefficient farmers could increase their inputs like, chemicals by 7.1 liters per acre, irrigation by 7.59 per acre and seed by 29.13 kgs per acre in order to achieve 100% efficiency level. These results have important and forereaching implications for the agricultural development of the state where arable land is becoming a binding constraint for sustaining the present yield.

Table 7. Average actual and target output and input quantities for inefficient farmers

variables	Unit	Actual	Slacks	Target	percentage
Output	Average	686227.3	4185.98	690413.28	0.61
Cultivated area	Average	3.80	1.5	5.3	39.47
Labour	Average	108.18	-14.56	93.59	-13.48
Chemicals	Average	51.25	7.18	58.42	14.01
Irrigation	Average	43.7	7.59	51.29	17.37
Seeds	Average	134.21	29.13	163.34	21.70
Fertilizers	Average	2150.70	-365.62	1785.08	-17.00

Source: Author's Calculations

4.4 Tobit Regression Model Results

In the first stage of the analysis, the technical efficiency of individual farms was estimated by the *DEA.* As the production frontier in the DEA approach is deterministic, the resulting efficiencies include noise from data. Therefore, in the second stage of the present analysis, the determinants of inefficiency were computed by using Tobit Regression Model. The estimated results are presented in are presented in the Table No.8. The model was absolutely fit since the F-test is 0.036 and it is strongly significant at 1% level. In addition, the pseudo R^2 is 33.65%. Among the selected variables, six (namely Farm Experience, Farm Size, Occupation, Membership, Seed Type and Household Size) were found to have a significant contribution on technical efficiency.

Age of the household head showed a negative effect on technical efficiency of the farms but the relationship is not significant. The results suggest that an increase in the farmer's age by one year reduced the level of probability of technical efficiency by 0.04%. This implied that aged farmers were less technically efficient than their younger counterparts. This could be possibly attributed partly to psychological (attachment to traditional ways of farming) and partly economic factors (aged farmers are generally risk averts). Similar conclusions were found by (Sibiko et al., 2012); (Padilla-Fernandez & Nuthall, 2009)].

Education was found to be positively related to farm efficiency but the relationship was not significant. The calculated results suggested that one year of increase in schooling will increase the farm efficiency by 0.4%. More educated respondents were likely to be more efficient compared to their less educated counterparts. Plausible reasons for positive correlation could be their better skills, access to information and good farm planning. These understandably might have helped the sample respondents to make better technical decisions and enabled them to allocate inputs efficiently and effectively. Similar results were reported by (Bravo-Ureta et al., 1997); and (Coelli & Battese, 1996).

Farming experience had positive and significant (at 10% level) impact on technical efficiency level of the farms. This implied that farmers with more years of experience were technically efficient because of learning-by-doing. However, the impact of experience on technical efficiency turned out nonlinear which have been captured by the quadratic variable (*Experience Square*). The coefficient of E*xperience Square* was negative and significant (10% level). It indicates that technical efficiency first increased with the experience only up to a certain level beyond which it had negative impact on technical efficiency. This may be attributed to the fact that farmers with more years of farming experience are aged people. As reported above, the age coefficient was negative while experience was positive. Similar results were reported by (Padilla-Fernandez & Nuthall, 2009) who concluded that experience is a better predictor of technical efficiency than age for sugarcane farmers in Philippine.

(Kalirajan & Shand, 1985) also reported experience to be a better predictor of production efficiency.

Table 8. Tobit Regression Estimated Results of Factors Influencing Technical Efficiency

Variable	Coefficient	Std. Err.	t	Significance
age	-0.00043	0.001377	-0.31	0.753
education	0.00495	0.007535	0.66	0.512
Experience	0.009234	0.005097	1.81	0.071**
Experience Square	-0.00012	7.45E-05	-1.67	0.096**
occupation	-0.05958	0.032609	-1.83	0.068**
Household size	0.007067	0.003527	2	0.046*
membership	0.042118	0.024832	1.7	0.091**
Farm size	-0.01089	0.00434	-2.51	0.013*
Farm size square	0.0083894	0.00507	1.68	0.095**
Seed Type	0.03801	0.02277	1.66	0.099**
distance	-0.01551	0.017598	-0.88	0.379
Household Assets (Rs 000)	3.11E-08	2.82E-08	1.1	0.271
Constant	0.268443	0.125468	2.14	0.033
Log Pseudo Likelihood = -19.949276 Number of observations = 461, F(48, 413) = 1.91 Pseudo R^2 = 0.3365 Prob > F = 0.0363				

Source: Field survey data,
Note: *significant at 5%, ** significant at 10%.

The farmer's primary occupation showed a negative effect on farm technical efficiency. The estimated results suggested that as soon as occupational pattern underwent a shift from (from farming to other occupation such as employment, business or any other income generating activity) the probability level of technical efficiency decreased by 5.9%. Farmers whose main occupation continued to be farming were expected to have lower efficiency than those engaging in employment or businesses or any other income generating activity. Other professions (subsidiary occupations) generated assured and regular supply of additional disposable income. This in turn enabled them to finance their farming activities. Similar results were reported by (Sibiko et al., 2012).

Group membership showed a positive and significant relationship with farm technical efficiency. Membership was used as a dummy variable. The estimated results revealed that having a membership of a group the probability level of technical efficiency increased by 4.1% compared to the non-member counterparts. The importance of membership in farmer organizations was also reported by (Tchale, 2009) among smallholder crop producers in Malawi. Collectively they observed that farmers who were members in an organizations were able to benefit not only from the shared knowledge among themselves with respect to modern farming methods, but also from economies of scale in accessing input markets as a group. Hence, such farmers become technically efficient.

Household size is an important variable especially in Indian agriculture which is labour intensive. Our results showed that the household size was positively correlated with technical efficiency and at 5% level of significance. The result suggested that with the increase in the number of family members the probability level of technical efficiency of farmers also increases. The plausible reason for this could be that the large household size enhanced the availability of labour which might have removed any labour constraint. Similar results were reported by (Mbanasor *et al.,* 2008).

Farm size was found to have a negative effect on technical efficiency and it was significant at 5% level. It may be argued that farmers with small farms use the land diligently, which reduces the loss in soil fertility level hence making them more productive. But square of farm size was worked out to be positive and was significant at 10% level. The results revealed that efficiency decreases up to a certain level then it increases with increase in farm size. Results implied that large farmers were technically efficient. Large farmers generally cultivate land by using new methods/techniques of production which may thereby affecting productivity and increasing technical inefficiency. In other words, when a farm is relatively small, farmers combine their resources better but increase in farm size up to certain level efficiency decreases. (Tchale, 2009); concluded that farm size was inversely related to efficiency. However some studies such as (Bravo-Ureta & Pinheiro, 1997) do not agree with these findings though their results.

Technical efficiency in agricultural productivity was found to be positively related to household assets though not significant. The results indicated that owned household assets led to an increase in the probability level of technical efficiency by 0.03%. (Sibiko et al., 2012) reported that owning household assets were important to access credit by which farmers can purchase agricultural implements and other assets like motor vehicles, tractors, bicycles and animal carts. These in turn increase farmer's mobility and provide them assured and quicker means of transportation, access to markets. They can also help in terms of income that enhances the available capital and improves farming investments. The results were similar to (Tchale, 2009) who estimated that owned household assets were used as a tool by which the framers liquidity position enhanced thereby raising farm productivity through higher input access.

The improved variety of seeds sown is critical variable to improve productivity efficiency among farmers. The relationship between seed type and farm efficiency was found positive but insignificant at 5% level. It indicated that farmers using improved seeds increased the level of productivity efficiency. Due to insignificant relationship farmers, however, did not benefit even by using improved seed varieties. This illustrates that modern varieties of seed increases technical efficiency of farming productivity but benefits could not be expected by default.

Distance between respondents home and farm land showed a negative effect on technical efficiency of farm productivity but the relationship was not significant. The estimated results implied that an increase in the distance to the farm land by one kilometre led to decrease in the farm technical efficiency by 1.5%. This could be attributed to the fact that farther the farm from the respondent's home greater was the cost of: transport, management, supervision and opportunity cost. This in turn hindered the optimal application of farm inputs and led to technical inefficiency. Many states in India, including Jammu and Kashmir, initiated consolidation of holdings as early as 1950s as a policy response to this problem. But these programmes did not achieve the desired results. This calls for new policy responses such as pooling of land holdings or land exchanges for cultivation while retaining ownership rights.

5. Conclusions

Non-parametric Data Envelopment Analysis (DEA) was used to estimate the technical efficiency using farm level field survey data of 461 farmers in study area for the year 2013-14. On an average, the respondents are able to obtain around 48% of potential output from a given mix of inputs. This also implies that around 52% of production, on an average was foregone due to technical inefficiency. Technical efficiency varies across farm size groups. Farm size and productivity efficiency relationship was found to be non-linear, with efficiency first falling and then rising with size. Large farms tend to have higher net farm income per acre and are technically efficient compared to other farm size categories. The scale efficiency was low relatively to the technical efficiency under variable returns to scale. The estimated results indicate that average level of Scale Inefficiencies (SIE) in the farming sector in the study area were to the tune of about 53% which has serious consequences and should not be overlooked. Only 18.7% of farmers were operating at MPSS. Majority of farms were operating with increasing returns to scale (77.8%). Three percent farmers operate under decreasing returns to scale. The estimated results further revealed that on an average, 14.01% of Chemical pesticides, 17.37 of intensity of irrigation, 21.70% of improved seed could be theoretically increased. The result further suggested that the inefficient farmers have decreasing returns to scale in two inputs (labour and fertilizer). Approximately 14% labour and 17% fertilizers could be reduced if all the inefficient farmers operate at the same level as the efficient farmers. Or on an average, inefficient farmers could have increased their output by 0.61% by using the same resources. Inefficient farmers can reduce 14.56 man days per acre and 365.62 kgs of fertilizers per acre in order to reach on efficient frontier. The analysis further indicates that efficiency level increases with increase in land size after 5.3 acres. Efficiency results across the two categories of farmers indicating that small farmers perform relatively better than medium farmers but worse than large farmers. Productivity is high in large farms because of technically efficient (as shown in table No.3) as compared to small and medium farms. Scale rather than technical efficiency is a major source of overall inefficiency. On the basis of these results we can assume that for the state as whole scale inefficiency is a serious issue and needs to be investigate across districts. The results also showed that there is an urgent need to expand the production base of agriculture with emphasis on small and medium farmers as more than 80% of the ownership holding of the state fall under this category. This calls for appropriate technological innovations, institutional alternatives and introduction of novel instruments of intervention. From a policy point of view, it should be noted that farm experience, occupation, household size, membership, farm size and seed type were the variables which could prop up the efficiency level of farms.

The estimated results from Tobit Regression, showed that farm experience, occupation, household size, membership, farm size and seed type have significant influence on the farm level technical efficiency. Policymakers should therefore foster the development of the socio-economic, institutional and farm specific factors to build the capacity and management skills of farmers. It is also be pointed out that the public sector must be predominantly be involved in the provision of information and technical assistance to farmers as a means to improve efficiency levels. There is also need to create general awareness about the available knowledge, skills and techniques to enhance farm productivity and quality of food grains so that the farmers could earn a sustainable income. Even though the farms in J&K are superior in terms of production performance, but they are weak in terms of generating adequate income and sustaining livelihood. In view of the growing scarcity of arable land state should put in place an effective mix of Command and Control Measures and Market Based Instruments to increase the sustainable yields. This calls for investment in farm research, extension programmes and skilled education to farmers.

References

Amemiya, T. (1981). Qualitative response models: a survey. *Journal of Economic Literature* 191:1483-1536

Bhagwati, J. N. & Chakravarty, S. (1971). "*Contribution to Indian economic analysis: A survey"*, Lalvani Publishing House;

Banker, R. D, Charnes, A. & Cooper, W. W. (1984). "Some models for estimating technical and scale in-efficiencies in data envelopment analysis", *Management Science* 309: 1078-92.

Beg, M. A. (1951). "*On way to golden harvests- agricultural reforms in Kashmir"*, Printed and Published by the Land Revenue Officer, Jammu and Kashmir Government, Ranbir Government Press, Jammu

Bhalla, S. (1979). Farm size and productivity and technical change in Indian agriculture. In R. A. Berry & W. R. Cline Eds.. *Agrarian Structure and Productivity in Developing Countries* pp 141-93. Baltimore: John Hopkins University Press.

Bhalla, S. S. & Roy P. (1988). Mis-specification in farm productivity analysis: the role of land quality. *Oxford Economic Papers* 40: 55-73.

Bhardwaj K. (1974). *Production conditions in Indian agriculture- A study based on farm management Surveys*, Cambridge University Press

Bhat, M. L. (1963). Land reforms in j and k stale a review. *AICC Economic Review*, 1:1-12

Bhatt, M. S. & Alam, S. N. (1987). Impact of new agricultural strategy on farm income distribution in anantnag distract of Jammu and Kashmir. *Agricultural Situation in India 44:* 27-32.

Bhatt, M. S. (1993). Land distribution in rural J&K: an inter-temporal analysis. in B. K. sinha & pushpendra eds. *land reform in India: an unfinished agenda*. Sage: New Delhi.

Bhattacharya, N. & Saini G. R. (1972). Farm size and productivity: a fresh look. *Economic and Political Weekly* 726:A63-A72.

Binswanger, Hans P. & Rosenzweig M. R. (1986). Behavioural and material determinants of production relations in agriculture. *The Journal of Development Studies* 223:503-539.

Bravo-Ureta, B. Solı´s, D. Moreira, V. Maripani, J. Thiam, A. & Rivas, T. (2007). Technical efficiency in farming: A meta-regression analysis. *Journal of Productivity Analysis* 27: 57–72.

Bravo-Ureta, B. E. & Pinheiro A. E. (1997). Technical, economic, and allocative efficiency in peasant farming: evidence from the Dominican Republic. *The Developing Economies* 35: 48–67.

Carter, M. R. (1984). Identification of the inverse relationship between farm size and productivity: an empirical analysis of peasant agricultural production. *Oxford Economic Papers* 361:131-145.

Chada G. K. (1978). Farm size productivity revisited: some Notes from recent experience of Panjab. *Economic and political Weekly* 1339: A78-A96.

Chand, R. P. A. Lakshmi Prasanna & Aruna S. (2011). Farm size and productivity: understanding the strengths of smallholders and improving their livelihoods. *Economic and Political Weekly* 46:26-27.

Charnes, A, Cooper, W.W. & Rhodes, E. (1978). Measuring the efficiency in decision making units. *European Journal of Operational Research* 26: 429-44.

Chattopadhyay, M. & Rudra A. (1976). Size-productivity revisited. *Economic and Political Weekly* 1139: A104-A116.

Chattopadhyay, M. & Sengupta A. (1997). Farm size and productivity: A new look at the old debate. *Economic and Political Weekly* 32:A172-A175.

Coelli, T., Rahman, S., Thirtle, C. (2002). Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: a non-parametric approach. *Journal of Agricultural Economics* 533: 607–626.

Coelli, T. J. & Battese, G. E. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. *Australian Journal of Agricultural Economics*, 40:103–128.

Coelli, T. J. Rao, P. & Battese, G. E. (1998). *An introduction to efficiency and productivity analysis*: Kluwer Academic Press.

Farrell, M. J. (1957). The Measurement of productive efficiency. *Journal of the Royal Statistical Society (A, general)* 120: 253–281.

Fan, S. & Chan-Kang, C. (2003). Is small beautiful? Farm size, productivity and poverty: In *FAO (Food and Agriculture Organization of the United Nations). 2004. FAO Statistics Division, World Census of Agriculture, 1980, 1990, 2000 rounds.*

Featherstone, A. M., Langemeier, M. R., Ismet, M. (1997). A nonparametric analysis of efficiency for a sample of Kansas cow farms. *Journal of Agriculture and Applied Economics* 29, 175–184.

Feder, G. (1985). The relation between farm size and farm productivity: the role of family labour, supervision and credit constraints. *Journal of Development Economics* 18 2/3: 297–313.

Government of India, (2010-11). "*Agriculture Census: All India report on number and area of operational holdings."* Ministry of Agriculture, Department of Agriculture and Cooperation Directorate of Economics and Statistics New Delhi.

Government of Jammu and Kashmir (1971). "*Agricultural Census Reports",* 1976, 1981and 1985

Gujarati, D. N. (2003). *Basic econometrics*. Mc-Graw: Hill Publishing Company New Delhi.

Gupta B. B. R. K. Salgotra & Bali A. S. (2009). Status paper on rice in Jammu and Kashmir, *Rice Knowledge Management Portal RKMP*. Accessed February 2014 Available at: http://www.rkmp.co.in.

Hazell, P., C. Poulton, S. Wiggins, & Dorward A. (2007). The future of small farms for poverty reduction and growth. 2020 Discussion Paper 42, Rome, International Food Policy Research Institute.

Helfand M. S. (2004). Farm size and the determinants of productive efficiency in the Brazilian center-west. *Journal of Agricultural Economics* 311: 241-49.

Jha, R. & Rhodes M. J. (1997). Technical efficiency, farm productivity and farm size in Indian agriculture. *International Food Policy Research Institute IFPRI.* Green Revolution Curse or Blessing. Accessed January 2014, available at:
http://www.ifpri.org/sites/default/files/pubs/pubs/ib/ib11.pdf:

Kalirajan, K. & Shand, R. T. (1985). Types of education and agricultural productivity: A quantitative analysis of tamil nadu rice farming. *Journal of Development Studies 212: 232–43.*

Khusro, A. M. (1964). Returns to scale in Indian agriculture. *Indian Journal of Agricultural Economics* 19: 51-80.

Kumar A. et al. (2013). Technology adoption studies on different extension methods for enhancing fruit production in District Pulwama of Jammu and Kashmir. *African Journal of Agricultural Research* 838:4882-4886.

Kumar P. & Mittal S. (2010). Agricultural productivity trends in India: sustainability issues. *Agricultural Economics Research Review* 19:71-88

Long, J. S. (1997). *Regression models for categorical and limited dependent variables. advanced quantitative techniques in the social sciences number 7.* Sage Publications:

Maddala, G. S. (1999). *Introduction to econometrics,* Macmillan Publishing Company: London.

Mazumdar D. (1965). Size of farm and productivity: a problem of Indian peasant agriculture. *Economica* 32: 161-7332.

Malik A., Hussain A. (2012). Agrarian Transformation in Jammu and Kashmir: A Case Study of a Village. *International Journal of Social Science Tomorrow* 1:1-5

Mbanasor J. A. & Kalu K. C. (2008). Economic efficiency of commercial vegetable production system in akwa ibom state, Nigeria: a translog stochastic frontier cost function approach. *Tropical and Subtropical Agro ecosystems* 81:313- 318.

Nair, K. N. (1990). "*Structural change in land holdings in India",* IDPAD Occasional Papers and Reprints, ICSSR / IMWOO, August

Nyagaka, D. O., Obare, G.A., Omiti, J.M., Nguyo, W. (2010). Technical efficiency in resource use: evidence from smallholder Irish potato farmers in nyandarua north district, kenya. *African Journal of Agricultural Research* 5: 1179-1186.

Olagunju F. I. & Adeyemo R. (2007). Agricultural credit and production efficiency of small scale farmers in south-eastern Nigeria. *Agricultural Journal* 2: 426-433.

Padilla-Fernandez, M. D. & Nuthall, P. L. (2009). Technical efficiency in the production of sugarcane in central Negros are, Philippines: An application of data envelopment analysis. *Journal of International Society for Southeast Asian Agricultural Sciences.* 151: 77-90.

Rao Hanumantha C. H. (1966). Alternative explanations of the inverse relationship between farm size and output per acre in India. *Indian Economic Review* 12:1-12.

Rao Hanumantha C H. (1975). *Technological change and distribution of gains in Indian agriculture.* New Delhi: Macmillan.

Sen, A. K. (1962). An aspect of Indian agriculture. *The Economic Weekly* 14: 243-46.

Sen, A. K. (1964). Size of holdings and productivity. *The Economic Weekly* 16: 323-26.

Shanmugam, K. R. & Venkataramani, A. (2006). Technical efficiency in agricultural production and its determinants: An exploratory study at the district level. *Indian Journal of Agricultural Economics* 612:169-184.

Shanmugam, K. R. (2003). Technical efficiency of rice, groundnut and cotton farms in Tamil Nadu. *Indian Journal of Agricultural Economics* 581: 101-114.

Sibiko K. W. et al. (2012). Analysis of determinants of productivity and technical efficiency among smallholder common bean farmers in eastern Uganda. *Current Research Journal of Economic Theory* 53: 44-55.

Thapa S. (2007). The relationship between farm size and productivity: empirical evidence from the Nepalese mid-hills: MPRA Paper No. 7638. Accessed January 2014, Online available at http://mpra.ub.uni-muenchen.

Tchale, H. (2009). The efficiency of smallholder agriculture in Malawi. *AFJARE* 32, World Bank, Lilongwe, Malawi.

Thorner. D. (1953). "*The kashmir land reform some impressions"*, *The Economic Weekly* 5: 26-37.

Zhu, J. (2003). "*Quantitative models for performance evaluation and benchmarking*", Kluwer: Academic Publishers, London.