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Agricultural Production performance on Small farm holdings:

Some Empirical Evidences from Bihar, India

R. K. P. Singh[1], Abhay Kumar[2], K. M. Singh[3] and Anjani Kumar[4]

Abstract

Immediately after the green revolution period, there was an intense debate on the observed inverse relationship between farm size and per hectare agricultural productivity in India. It was subsequently argued that the higher productivity of small holdings would disappear with the adoption of superior technology, modernisation and growth in general. Recently, National Sample Survey data show that small holdings in Indian agriculture still exhibit a higher productivity than large holdings. This article contributes to the limited literature on farm size and productivity in small land holder's agriculture in Bihar, India. Plot wise panel data of VDSA project are used to reach at precise conclusion. The results provide evidence for a positive relationship between farm size and productivity in case of small land holders' agriculture and hence, an inverse relationship does not seem to apply within small landholders' agriculture. A strong positive relationship between farm size and output per hectare is a result of higher use of fertilizer, modern seeds and irrigation sources on comparatively larger land holders than small land holders in Bihar, India. It is mainly due to more uneconomic land holdings of sub-marginal and marginal farmers to have limited access to water resources, quality input and credit. Access to resources and technology must be considered together for any agricultural development programmes for small land holder's agriculture. It is therefore needed to look for ways of improving their access to resources for farming through increased opportunities for earning off farms and off season income or through improved credit market. Hence, small size and land fragmentation are key bottlenecks for the growth of agriculture in Bihar, India.

The crop productivity of tiny landholders can be increased through improving their access to institutional financing system, agricultural extension network and farm technology centres. However, promotion of non-farm rural employment seems to be the most appropriate option for increasing crop productivity and improving livelihoods of small landholders in Bihar.

Key words: farm size, productivity, small landholders' agriculture, Bihar, livelihood, adoption of modern technology

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Introduction:

Relationship between farm size and productivity in developing countries has been one of the oldest issues of the interest of researchers. The debate on farm size and productivity relationship intensified, when Sen (1962) observed inverse relationship between farm size and output per hectare in Indian agriculture, suggesting that small farms are more productive compared to large ones. Several studies confirmed the phenomenon in Indian agriculture and its statistical validity was adequately established (Mazumdar, D. (1965), Khusro (1968), Hanumantha Rao (1966) and Saini (1971)). Usha Rani's (1971) studies in Intensive Agricultural Development Programme (IADP) districts using farm level observations showed that neither cropping pattern nor inputs intensity nor even yield per acre differs across farms of different sizes. Krishna Bharadwaj (1974) also investigated the relationship between productivity and size of farm and found that in the majority of cases, an inverse relationship existed; however, it was not statistically significant.

Chadha (1978) while studying farm level data for three agro-climatic regions in Punjab found that the inverse relationship had ceased to hold in the more dynamic zones. However, Rudra (1983) opined that there is no scope for propounding a general law for an inverse relationship or even for a positive relationship. A recent study by Chattopadhyay and Sengupta (1997), suggested that the inverse relation between farm size and productivity became stronger in the agriculturally developed regions of West Bengal compared to the relatively less developed regions.

Despite a number of studies favouring the inverse relationship, it has failed to reach a consensus. On the contrary, some studies concluded that the adoption of new agricultural technology by large farmers has reduced or even reversed the yield advantage of small farmers (Fan Shenggen and Connie Chang Kang, 2005). Recent

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literature also shows that small farms are not as efficient as large farms in agriculturally developed regions but they could be more efficient in agriculturally backward regions (Kazi and Toufique, 2005).

To sum up, it is often pointed out that the difference in the size of farms is one of the reasons for the difference in yields. It is argued that small cultivators increase cropping intensity on their farms or have multiple crops and that family labour works intensively on such farms thereby increasing output per unit of land. However, studies carried out on the relationship between size of farms and productivity show contradicting results.

The objective of this paper is to test the inverse relationship between farm size and productivity and identify the changes, if any, with the introduction of modern technology in agriculture, particularly in context of small holders' agriculture. We have estimated productivity and input use in all the crops grown by farmers on an annual basis and used them to compare performance of the entire system of land-based activities across various farm size categories. Agricultural development indicators like; cropping pattern, intensity of cropping, use of chemical fertilizers, modern seeds and irrigation resources have been also examined for different categories of farm households.

The paper investigates the farm size –productivity relationship amongst smallholder farms of Bihar province of India. Bihar is the most suitable region for studying farm size and productivity relationship on farms of small land holders because there is high population density (1102/sq. km.) and very small landholdings (0.39 ha.). Marginal size of land holdings (< 1 ha.) constitute 91 percent of total farm holdings and possess 57 per cent of cultivated land and their average size of landholdings is 0.25 hectare (Government of India, 2012). Number of land holdings

increased from 11.6 million in 2001-02 to 16.2 million in 2010-11 (39.7%) whereas increase in marginal land holdings was much faster (51.5%) from 9.7 million to 14.7 million during the period (Appendix-I).

Data and Methodology:

The data used in this study were collected under ICRISAT- ICAR collaborative project entitled "Tracking Changes in Rural Poverty in Households and Village Economies in South Asia." In the project, data are being solicited from the panel of 40 households in each of four sample villages in Bihar. Data are being collected by resident Investigators. For the selection of respondents, development indices of all the districts were worked out on the basis of per hectare agricultural GDP, infrastructure (density of rural roads, extent of electrification, density of PHC and bank branches) and education level. Districts were arranged in descending order on the basis of development indices. Data set of districts of the state was categorized in three quartiles. One district from lower quartile (consisting less developed districts) and another one from upper quartile (consisting of comparatively developed districts) were randomly selected for drawing sample of blocks. One block from each sample district, making two sample blocks were also selected randomly. List of villages were prepared for each sample block and two villages from each sample block were selected randomly. The census was conducted in four sample villages through the structured schedule containing questions about demographic characteristics, land ownership, livestock, and agricultural machineries possessed by households in the village, etc. Households of sample village were arranged in ascending order on the basis of their land area. Households owning land less than 0.20 hectare were categorised as labour households and quartile of remaining households of villages were formed, upper quartile was categorized as marginal households, middle as

small households and lower as large households. Sample of 10 households from each category were randomly selected, making sample of 40 households in each village. Thus, a total of 160 sample households were selected in Bihar for detailed investigation.

In sample villages, farm holdings up to 1 hectare constitute 76 per cent of total farm holdings and there are only five farmers who were having more than 4 hectares of land and cannot be categorised as a group for analysis. Hence, analysis of data relating to farm size, productivity and other components were undertaken by re-categorizing of sample households in four groups that is; sub-marginal (<0.40 ha), marginal (0.40-1 ha), small (1-2 ha) and medium farm households (2 ha and above).

Cropping Intensity and Cropping pattern:

Cropping intensity is a major source of agricultural growth in the country. There has been very slow growth of cropping intensity in most of Indian states and it varies widely from one region to another. The cropping intensity also varies with area of land operated by farm households. The inverse relationship between farm size and cropping intensity has been observed in various studied (Bharadwaj 1974, Griffin 1974, Berry and Cline 1976, Khan 1979 and Ramesh Chand, Prasanna P. A. L and Singh, A. 2011). Sau (1978) also observed low cropping intensity on large farms and concluded that there is an inverse relationship between farm size and cropping intensity in few Indian states. Sen (1964) argued that small farms being family enterprises had a lower cost of labour as compared to large farms. So small farms are cultivated more intensively and produce a higher level of output.

The cropping intensity of four categories of farms under study has been worked out to find cropping intensity on different categories of farm households in Bihar, India. The cropping intensity was comparatively high on marginal households

(183) and low on medium households (163%). However, cropping intensity was identical on sub marginal and small households (Table 1). There is no clear cut trend of cropping intensity on different size of farm holdings but upper category of farm households had the lowest level of cropping intensity.

The log linear form of the model was also applied to know the relationship between cropping intensity (CI) and farm size. The estimated regression coefficient is (-) 0.577. The negative values of b in the model clearly indicates the negative relationship between CI and farm size but the coefficient of the CI is not found significant at even 10 % level of significance (Appendix II).

Marginal farmers cultivated vegetables and spices on comparatively large area due to availability of family human labour for frequent inter culturing, irrigation, pest management and supervision of these crops. The upper (medium) categories of farm households cultivate wheat in larger proportion of area in *rabi* season whereas other categories of households cultivate two crops of vegetables and spices in almost same period. These crops are short duration crops which helped increasing cropping intensity on smaller size of farms.

Cropping Pattern:

Cropping Pattern is the crop - mix grown in a particular piece of land in an agricultural year. Introduction of new agricultural technologies has introduced a new crop – mix, which is more prominent in agriculturally developed area. Cropping patterns are affected by a multiplicity of factors of which the resource position is one, which is mainly determined by size of land holdings and non-farm income. While analysing cropping pattern of households under study, food grain emerged as most important crops which were grown on about 95 per cent of gross cropped area of households under study. A comparatively large proportion of gross cropped area

was put to food grains crops on medium size of farms (95.85) and lower on smaller categories of households (Table 2). Rice and wheat jointly cultivated on about 94 per cent of gross cropped area on upper category (medium) farms. None of category of households cultivated rice and wheat on less than 87 per cent of their gross cropped area. Sub-marginal and marginal households put comparatively larger proportion of area under spice and vegetables, mainly due to availability of more family labour on these households. These crops are also more remunerative and these categories of households try to earn more from their small piece of land. These results show that the production of staple food is a dominant consideration in all size categories of households. This is mainly due to consideration of family consumption requirements on all categories of households under study. It was also partly due to almost assured price of these crops through procurement centres. These crops are also less labour intensive than spices and vegetable crops.

The above discussion does not lead to clear conclusion that farm categories under study differ from each other with respect to their cropping pattern. Hence, Kendall's coefficient of concordance was used to test the compatibility of cropping pattern followed on different categories of farms under study. The calculated value of Chi square (28) is lower than table value of $\chi^2_{21,\ 0.05}$ indicating that the ranking of crops in the cropping pattern on four categories of households were compatible (Appendix III). This finding clearly indicates that there has been a significant difference in cropping pattern followed by farm categories under study. The cropping patterns of all categories of households are dominated by food grains but upper category of households (medium and small households) put more area under rice and wheat whereas sub marginal and marginal categories of households (<1 ha.) cultivated spices and vegetables on comparatively large proportion of area. Upper

category of households cultivated wheat on larger proportion of their land in *rabi* season but sub- marginal and marginal households preferred cultivation of spices and vegetables. However, categories of households under study do not differ significantly with respect to their cropping patterns.

Seed Replacement Rate:

Seed is the most important critical determinant of crop production on which the performance and efficacy of other inputs depend. Sustained increase in crop production and productivity necessarily requires continuos development of new and improved crop varieties and efficient system of production and supply of seeds to farmers. An atempt has been also made to analyse the farm category wise seed replacement rate of rice and wheat because these two crops cover about 95 per cent of cropped area on farms under study.

In study villages, seed replacement rates of rice and wheat were 61.68 per cent and 71.76 per cent, respectively on households under study (Table 3). The seed replacement rates of the two principal crops were much higher because Government of Bihar made massive efforts for increasing rice and wheat seed replacement rates. But seed replacement rates in case of both crops were much higher on medium size of farms and it declined with decline in size of farm holdings.

The comparatively low level of seed replacement rats of both the principal crops on smaller size of farm households was mainly due to their poor access to subsidized seeds. Seed replacement rate was higher on small and medium households because more than 50 per cent of them could afford to purchase seeds from market also however, sub- marginal and marginal farmers could not afford to

purchase seeds from market due to poor liquidity and high price of seeds in the market.

Fertilizer use:

Use of chemical fertilizer helps increasing productivity and production of crops. Use of fertilizer in cultivation of various crops has been examined on different categories of households under study. Per hectare use of fertilizers in cultivation of all crops on households under study was 162 kilograms but medium category of households applied higher quantum of fertilizer (182 kgs/ha.), which declined with decline in size of land holding (Table 4). Medium farmers used 72 per cent more chemical fertilizers than sub-marginal farmers in crop production. Per hectare use of fertilizer in rice, wheat, oilseeds and vegetables were also higher on medium farms which declined with decline in size of holdings. Sub-marginal farmers used about half of fertilizer in rice, 73 per cent in wheat, about one-fourth in oil seeds and less than half in vegetable production than the corresponding level of fertilizer use by medium farmers. Smaller categories of households are resource poor and they could not afford to buy required quantity of fertilizers, particularly phoshphatic and potassic fertilizers, which are costly in the market. They are also making unbalanced use of fertilizers in crop production, which is resulting in to comparatively low yield of crops.

Crop productivity:

An attempt has been also made to examine the relationship between per hectare productivity of various crops cultivated on different categories of households under study. While examining the farm size crop -productivity relationship, the comparatively high productivity of all crops was observed on upper (medium) category farms and lower on smaller size of farm categories with some minor

exception (Table 5). Per hectare total value of crop output (main + by-product) was also worked out by multiplying with respective market prices. In this case also, medium farm households realized higher per hectare gross income than smaller categories of farms from various crops cultivated by them and the similar trend was observed. In other words, per hectare value of gross output declined with decline in farm size (Appendix IV).

Per hectare value of gross output was regressed with size of land holdings using log linear model. Estimates of per hectare value of gross output for different size of farm holdings suggest a positive relationship between farm size and productivity (Table 6). The results of this analysis suggest that the positive relationship between farm size and crop productivity exists in case of small land holders with scarce resources. It was mainly due to comparatively high level of adoption of farm technology like; modern seeds and fertilizer and ownership of irrigation resources by larger categories of farm households (Appendix IV). Smallholders failed to get benefits of modern agricultural technology due to their poor access to technology and institutional credit. Their tiny land holdings (<0.20 ha.) also hindered the adoption of new technologies.

Theories about disappearing advantages of marginal and small farmers and efficiency gains of comparatively large categories of farmers with economic development holds true in small land holders' agriculture in Bihar

Conclusions:

The paper aims at examining the farm size-productivity relationship on small land holders' farms in resource scarce area in Bihar, India. Using regression analysis to household level panel data of farm households a positive relationship between farm size productivity is demonstrated. The higher productivity of various crops on

upper category of households was mainly due to use of modern seed and fertilizers and ownership of water resources. Poor access to working capital to procure modern seeds, fertilizers and water resources for timely adequate irrigation to crops are major constraints for realizing higher crop productivity on tiny land holdings. This result is associated with prevalence of part time farmers cultivating on tiny and uneconomic land holdings. The size of medium category of households is also only 0.84 ha, but they have better access to technology and resources. The results also reflected the prevalence of poverty and lack of working capital for crop production in area of undeveloped infrastructure and non- existence of rural non-farm activities.

The crop productivity of tiny land holders can be increased through improving their access to institutional financing system, agricultural extension network and farm technology centres. However, promotion of non-farm rural employment seems to be most appropriate option for increasing crop productivity and improving livelihoods of small land holders in Bihar.

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Table 1: Cropping Intensity on different category of households, Bihar, India

Land class	Cropping intensity
Sub Marginal	175
Marginal	183
Small	175
Medium	163
Total	171

Table 2: Area under different crops on different categories of households, Bihar, India (in %)

Particulars	Sub Marginal	Marginal	Small	Medium	Total
Paddy	51.2	49.5	49.5	50.8	50.2
Wheat	38.1	38.3	41.7	43.1	41.3
Maize	0.6	0.2	0.0	0.0	0.1
Pulses	4.7	4.8	4.3	2.0	3.4
Food Grains	94.6	92.8	95.5	95.8	95.0
Oilseed	2.4	3.6	2.3	1.8	2.4
spices	0.1	0.1	0.1	0.0	0.0
Vegetable	0.8	1.5	0.7	0.4	0.8
Others	2.1	2.0	1.4	1.9	1.8

Table 3: Farm category wise seed replacement rate during last three years (%)

Farm size	Rice	Wheat
Sub- marginal	36.76	41.86
Marginal	43.59	54.83
Small	71.02	66.88
Medium	71.87	86.76
All	61.68	71.76

Table 4: Per hectare use of fertilizer (NPK) in various crops on different categories of farm households.

(kg/ha.)

Crop	Sub Marginal	Marginal	Small	Medium	Total
Rice	81	112	151	166	145
Wheat	156	191	208	213	203
Maize	81	191	neg.	neg.	143
Pulses	47	68	37	14	45
Oilseed	56	116	88	194	122
Spices	158	125	128	neg.	131
Vegetable	80	168	145	285	182
All crops	106	137	165	182	162

Table 5: Productivity of different crops (Kg./ha)

Crop	Sub Marginal	Marginal	Small	Medium	Total
Paddy	3485	3908	4641	4847	4493
Wheat	2450	2409	2847	3015	2805
Maize	5434	3242	neg.	neg.	4203
Pulses	384	382	445	771	485
Oilseed	229	238	447	960	442
Spices	473	206	91	neg.	192
Vegetable	9319	9276	12893	15438	11494

Table 6: Linear regression

Dependent variable = Main output ($/ha)			
Parameters	**Coefficient**	**Standard error**	**t-value**
Operated land	0.09969	0.02404	4.15
Constant	0.45589	0.03954	11.53
No. of observation	160		
R-squared	0.0982		
Adj R-squared	0.0925		

Appendices

Appendix I: Number of different categories of farm households and area own by them in Bihar during last 10 years

Farm categories	Number (in '000)			Area (in '000 ha.)			Average size (in Ha)		
	2001-02	2005-06	2010-11	2001-02	2005-06	2010-11	2001-02	2005-06	2010-11
Marginal (<1 ha.)	9743 (84.18)	13139 (89.64)	14744 (91.06)	2907 (43.08)	3313 (53.00)	3669 (57.44)	0.30	0.25	0.25
Small (1-2 ha.)	1069 (9.25)	978 (6.68)	948 (5.86)	1296 (19.21)	1224 (19.50)	1186 (18.56)	1.21	1.25	1.25
Semi-medium (2-4 ha.)	589 (5.09)	438 (2.99)	415 (2.56)	1544 (22.88)	1135 (18.15)	1073 (16.80)	2.64	2.59	2.59
Medium (4-10ha.)	164 (1.42)	98 (0.67)	81 (0.50)	861 (12.76)	505 (8.09)	415 (6.50)	5.24	5.15	5.12
Large (≥10 ha.)	9 (0.07)	4 (0.02)	3 (0.02)	140 (2.07)	74 (1.18)	45 (0.71)	15.50	18.50	15.00
All	11574 (100.00)	14657 (100.00)	16191 (100.00)	6748 (100.00)	6251 (100.00)	6388 (100.00)	0.58	0.43	0.39

Source: Agricultural Census-2010-11: All India Report on Number and Area of Operational holdings, Agricultural Census Division, Ministry of Agriculture and Cooperation, Ministry of Agriculture, Government of India

Appendix II: Log linear regression of Cropping intensity and farm size of households under study, Bihar, India

Independent variable	Cropping intensity (%)		
	Coefficient	Standard error	t-value
Operated land (ha)	-5.77	4.85	-1.19
Constant	191.59	9.29	20.61
No. of observation	118		
R-squares	0.012		
Adj R-Squared	0.0035		

Appendix III: Kendall's coefficient of concordance for cropping pattern followed on different categories of households under study, Bihar, India

Particulars of Concordance Test	Value
Estimated Coefficient of Concordance (W)	0.98
Estimated χ^2	20.55
Table Value of $\chi^2_{14,\ 0.15}$	19.4

Appendix IV: Farm category wise value of output of all crops grown on farms ($/ha.)

Crop	Sub Marginal	Marginal	Small	Medium	Total
Paddy	733.6	824.3	975.2	979.9	926.9
Wheat	724.7	709.2	765.4	761.4	748.6
Maize	1235.0	779.6	neg	neg	979.3
Pulses	184.9	270.9	343.2	616.8	357.9
Oilseed	161.6	226.8	311.7	644.5	331.9
Spices	404.8	180.9	117.0	neg	183.9
Vegetable	1112.6	1056.3	1407.3	1694.5	1284.4
All crops	669.3	693.9	833.3	867.6	803.4

Appendix V: Farm category wise ownership of pump set in study villages (% HH)

Farm category	% households
Sub-marginal	13.51
Marginal	38.30
Small	86.96
Medium	93.75
All	39.38

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