Status of Agricultural Technologies Adoption and Sustainable Intensification in Chickpea Crop in Rain-fed region: A study in Telangana and Andhra Pradesh in India

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Abstract

Chickpea is predominantly cultivated pulse crop in the selected study area in Telangana and Andhra Pradesh states in India. The performance of the chickpea crop has been impressive with a positive growth rate in area, production and productivity on adoption of the improved crop technologies (improved short duration varieties, package of practices, farm mechanization) in last three decades period. On this backdrop, present study taken up to analyze the household adoption behavior in adoption of improved agricultural technologies and their impact at farm level. Secondly to assess farm efficiencies and socio-economic and environmental sustainability of chickpea crop in the study area. The findings of the study reveals that, shortage of labour and crop profitability are statistically significant and positively influence chickpea cultivation in the study area whereas improved access to markets and increased support from financial institutions and extension departments may lead to crop shift and decline in chickpea cultivation in the study area. The calculated farm efficiencies explains that, on an average, farmers were able to obtain only 27.43 percent, 89.12 percent and 24.98 percent technical, allocative and economic efficiency respectively. Large landholding farms are more technically and economically efficient whereas marginal farms have achieved highest allocative efficiency. Farm level three dimensional crop performance analysis reveals that, the average crop efficiency achieved in chickpea crop is in the range of 30-60 percent across the different land holdings in the study area. Chickpea cultivation is more profitable on medium and large farm holdings than the marginal and small landholdings. The marginal and small farmers are incurring negative net returns while the medium and large farmers are able to get good average net returns. The social indicates infers that, there exists gender equity in work and income distribution of chickpea cultivation. The peer advice network is stronger compared to the informal and formal advice group in dissemination of crop technologies information in the study area. The environmental crop performance indicators witnessed efficient use of improved seed, unbalanced and excess use of fertilizers and poor application of FYM in chickpea cultivation farms. Constant use of machinery, in rainfed conditions without practicing the sustainable management practices resulted in lower technical and economical farm efficiencies in study area. The intensive cultivation of chickpea crop by using inputs disproportionately without practicing the sustainable management practices, constant mono cropping and failure to provide protected irrigation, poor institutional support are few factors that resulted in significant yield variation across the different land holdings and lower technical and economic efficiency of the chickpea farms in the study area.

Keywords: Agricultural Technologies, Adoption, Crop Performance Indicators**,** Chickpea, Farm Efficiencies,

Introduction: In India, chickpea remarkably predominates among other pulse crops in terms of area and production by holding a share of 36.77 percent and 45.72 percent respectively (2012-14). For the triennium period (2012-14) the average area under chickpea crop was estimated to be around 8.88 million hectares and average harvested produce was around 8.35 million tons with a highest average productivity of 957 kg/ha in India. Nearly 65 percent of chickpea is

grown in the country as a rain-fed crop and the remaining area is cultivated under irrigated conditions. Before the 1960s, chickpea was mainly cultivated in the northern states whereas in the southern states the area under chickpea was minimal. But during green revolution period chickpea crop cultivation was shifted to marginal and fragile lands in the central and southern states of India. Negative growth rates were registered in area, production and yields of chickpea during this transition period (1960-1990). From the mid-1990s, area and yield levels showed positive growth after the development and adoption of niche specific, drought and wilt resistant short duration varieties, increased farm mechanization which resulted in a significant increase in area, production and productivity of chickpea crop, especially in the southern states (undivided Andhra Pradesh, Karnataka and Maharashtra).

Problem statement: Given the rapid extensification and intensification of chickpea crop in non-traditional area (Telangana and Andhra Pradesh in India), the current study is intended to study the household adoption behavior in adoption of improved agricultural technologies (improved short duration seed, farm mechanization and practice of package of practices), and impact at the farm level. Secondly to assess farm efficiencies and sustainability of chickpea crop in the study area with the following specific objectives.

Objectives:

1) To study the adoption behaviour of chickpea farmers by focusing on socio-economic, and institutional factors.
2) To evaluate the farm efficiencies of the selected chickpea farms in Telangana and Andhra Pradesh states respectively in India.
3) To construct crop performance indicators in socio- economic and environmental dimensions in chickpea crop for its long term sustainability.

Review of literature

Existing literature reviewed, to understand the chickpea crop performance in rainfed regions, factors influencing the agriculture technologies adoption and sustainability aspects in socio economic and environmental dimension.

Chickpea cultivation witnessed a positive high growth both in area and production, low risk in undivided Andhra Pradesh (Telangana & Andhra Pradesh) during post- Independence period. (Amarender Reddy and Devraj Mishra,2006).A study from Cynthiya Bantilan et al., (2014) explained that, more than 90 percent of the area was under JG-11 seed variety followed by the other varieties namely Vihari, Kak-2, Nandyal Chana and bold variety in undivided Andhra Pradesh. The JG-11 is improved short duration semi spreading, bold seeded (22g/100 seeds) variety, matures in 95-100 days and is resistant to wilt and root rot which outperformed the traditional existing Annegiri variety. The JG- 11 variety on an average gave 23.9 percent higher yield and net returns of Rs.31, 986 per ha compared to Annegiri variety (Dattatri.K et al., 2010). During 1999 to 2011, about 95 per cent of the total sample farmers adopted JG- 11 (Cynthiya Bantilan et al., 2014; A. Amarender Reddy, 2015) and nearly 40-50 per cent yield advantage has been noticed compared to Annegiri variety in undivided Andhra Pradesh. (A.Amarender Reddy, 2015; Ramakrishna et al., 2005). Chickpea intensification is happening in a major way on the back of adoption of improved agricultural technologies such as availability of short duration

cultivars with disease resistance and improved mechanization in agricultural activities.
A study from Joshi et al., 2005 confirms that, increased chickpea prices, lower post rainy-season sorghum yield, and the availability of improved chickpea varieties suitable for the drought condition and disease resistance are the determinant of increased area under chickpea crop in Kurnool in Andhra Pradesh state. In addition to that, vagaries of the climatic conditions, low risk and assured returns with low crop maintenance (Suhasini, 2009) and availability of household labour, access to formal seed sources, price information, literacy, and subsidized seed (Suhasini, 2014) are the other factors contributed for area expansion under chickpea crop in the study area. Developments of varieties with traits such as low duration for crop maturity, suitability of soil, low yield risk are the other determinants of chickpea crop intensification in Gujarat (Shiyani *et al.,* (2001). A study from Mehta, 2013, reveals that, there is a strong linear relationship between the farm powers available and the agricultural output per ha. Mani et.al. (2008) also discusses that use of combine harvester on custom hire gained popularity in chickpea crop cultivation as the draught animals population was rapidly declining in the study area. In contrary to this, Das, (2012) study found that, small farms face serious problems in farm mechanization as it is a costly affair on individual ownership basis so, this is not economically viable in small and marginal farms. Apart from these factors institutional factors (Weitz et al., (1976); Individual behanviour (Rogers, (1995; Lindner and Pardey, 1979); gender differences (Doss (2001); Tiruneh et al., (2001); Jagger and Pender, (2006) and social capital and their networking strength (R.Padamaja, 2006; Boahene et al. 1999) are the other factors also influence the adoption of improved technologies.

A study from Bagi, (1982) states that, despite of higher rate of adoption of improved crop technologies, farm-level technical efficiencies was low in rainfed crops particular in the case of chickpea and technical efficiency were determined by education, fertilizer use, and input quality . A study results from Rahman et al., (2005) concluded that, socio- economic and demographic factors, farm plot level characteristics, environmental and non-physical factors are likely to affect the efficiency of smallholding farmers.

A study by David Tilmana,(2011) explains that the extensive use of crop land and adoption of improved technologies have contributed significantly to achieving higher crop production to meet the rising food demand globally but, on the other hand has resulted in a negative impacts on the environment by degrading the natural resource base . Sachdev et al. (1992) discussed the importance of balanced fertilization for increased yield and harvest index of chickpea. Shinde and Mane,(1996) reported that the balanced application of fertilizers based on soil testing improved the yield of chickpea by 47 percent and monetary returns by Rs. 7676 (US$171) per hectare. Multiple spraying of urea (60, 75 and 90 days after sowing) has the potential to enhance nitrogen content (3.09 percent) and protein content (19.31 percent) in chickpea grain under the moisture stress of rain-fed conditions. (Singh *et al.* 1994; Venkatesh and Basu, 2011). A study by R. Serraj et al., (2004) explains that, drought may cause complete crop failure or varying amounts of reduction in biomass and grain yield. A study from Pooran M.Gaur et al., (2007) states that, chickpea grown in the semi-arid tropical and Mediterranean regions, suffers substantial yield loss due to drought at the end of the growing season (terminal drought), as the crop is largely grown rain-fed condition in post-rainy season under progressively receding soil moisture conditions. At this level of development, there is a need to find farm efficiencies to analyse the impact of improved technologies on farming community.

In addition to that, crop performance indicators are constructed such as input use efficiency (Gowda and Jayaramaiah, 1998 ; Rasul and Thapa,2003), indicators on profitability and economic feasibility (Kuyvenhoven and Ruben, 2004), Social equity (Chambers and Conway, 1991), to understand the sustainability aspects of the chickpea crop in the study area.

Methodology

The proposed study is carried out in a rain-fed region in Telangana and Andhra Pradesh states for the crop year 2015-16. The selected states have significant shares in total chickpea production in the country with significant growth rate in area under chickpea crop in last two decades period. By adopting multi-stage stratified proportionate random sampling technique 320 chickpea cultivating and 80 control sample farmers(non-chickpea cultivating farmers) were selected in eight villages four each from the sampled two states. The primary data was collected on various aspects like socio-economic and institutional factors of the selected chickpea farmers, production per acre, physical inputs used pattern, cost and price of the output and inputs used and utilization pattern of different labour in the chickpea cultivating farms by administration of well-structured schedule and the data was scrutinized and analyzed by using suitable quantitative statistical tools.

Contribution to the literature: The findings of the study assists in understanding the adoption behaviour of the farmers with reference to improved agricultural technologies, chickpea farm efficiencies and crop sustainability in longer period. It may also serve as an aid for decision-making to the farmers and contribute to formulating policy recommendations and strategies based on farmers' need, interest and capacity in promoting sustainable agricultural intensification in chickpea cultivation in the rain-fed region for earning higher incomes by the farming households.

Method: For analysis combination of statistical tools used such as simple descriptive statistics, percentages and suitable econometric models. Logit regression analysis performed to identify the factors influencing or constraining the cultivation of chickpea crop cultivation in the study area. The frontier production and cost function analysis was carried out to assess the chickpea farm efficiencies and efficiency differences among the different land holdings in the study area. Finally, simple descriptive statistics were applied for calculating the three dimensional sustainable crop performance indicators in chickpea crop.

(i) Determinants of chickpea crop cultivation in study area

Binary logistic regression model is applied to the data for analyzing the probability of the respondents would prefer to cultivate chickpea or not by taking in to consideration the factors such as socio-economic factors of the respondent and institutional factors.

The empirical model for the binary logistic regression model estimation is specified as follows:

$$\text{In } (p/1-p) = bo+b_1X_1+b_2X_2+b_3X_3+\ldots\ldots+bn\ Xn\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where X_i is the combined effects of X explanatory variables that promote or prevent farmers' decision to cultivate chickpea crop

Where

In (p/1-p)= the log odds in favours of farm households decision to cultivate chickpea.

$X_1 ... X_i$ are factors that promote or prevent farm households from cultivating chickpea crop and are defined as follows:
Farm size in acres, gender of respondent, presence of livestock, age of respondent in years; formal education in years, number of years of chickpea farming, shortage of labour ,profitability of the crop, access to markets , financial institutional support, access to extension services, support fromthe private employees, reasonable output prices.

(ii) Estimation of the Chickpea Farm Efficiencies

In the present study, stochastic frontier production function adopted to estimate the efficiency of the selected chickpea cultivating farms empirically.

$$\text{Ln } Y_i = \beta_0 + \beta_1 \text{ Ln } X_{1i} + \beta_2 \text{ Ln } X_{2i} + \beta_3 \text{ Ln } X_{3i} + \beta_4 \text{ Ln } X_{4i} + V_i - U_i \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where

Y_i = quantity of the output per acre in quintals of i^{th} farm; X_{1i} = seed in Kgs of i^{th} farm; X_{2i} = fertilizer in kgs of i^{th} farm; X_{3i}= human labour in man days of i^{th} farm X_{4i}= machinery labour working hrs. of i^{th} farm; β= vector of unknown parameters to be estimated.

V_i is the (stochastic error term) random variable assumed to be independent and identically distributed as $N(0, \sigma v^2)$; U_i is non-negative estimate of farm technical inefficiency.

The selected frontier cost function in the study

$$\text{Ln } C_i = \beta_0 + \beta_1 \text{ Ln } Y_i + \beta_2 \text{ Ln } X_{1i} + \beta_3 \text{ Ln } X_{2i} + \beta_4 \text{ Ln } X_{3i} + \beta_5 \text{ Ln } X_{4i} + V_i + U_i \quad \ldots\ldots\ldots (2)$$

Where

C_i=total production cost (paid out cost) Y_i = Output value per quintals of i^{th} farm X_{1i} cost of seed of i^{th} farm; X_{2i} = cost of fertilizer of i^{th} farm; X_{3i}= human labour wage of i^{th} farm X_{4i}= machinery labour wage of i^{th} farm β_0 = constant; β_1- β_5 = parameters of the cost function; Ln = natural logarithm; The error term composed of two elements that it ($e_i = V_i + U_i$); V_i=random error due to statistical noise, weather, disease, etc., which are outside the control of the farmers; U_i= randomness (Economic inefficiency) due to farmers socio economic characteristics such as age, formal schooling, farm size and farming experience.

iii) Estimation of TE, AE and EE of sampled Individual Chickpea Farms

a) $TE_i = \frac{Y_i}{\dot{y}_i} = \frac{Y_i}{F(X_i;\beta)\exp(v_i)} = \frac{E(Y_i/u_i, x_i)}{E(Y_i/u_i=0, x_i)} = E[\exp(-U_i)/e_i]$

b) $EE_i = \frac{C_i}{\dot{c}} = \frac{Y_i}{F(X_i;\beta)\exp(v_i)} = \frac{E(\frac{C_i}{u_i}, y_i, x_i)}{E(\dot{c}_i/u_i=0, y_i\, x_i)} = E[\exp(-U_i)/e_i]$

c) AE= EE/TE.

Where,

Y_i is observed output; $\dot{y}_i$ corresponding frontier output; X_i are independent variables, U_i = error term; Total Production cost (C_i) to actual total production cost C. This efficiency measure takes value between 0 and 1 with smaller ratios reflecting the greater inefficiency of the farms.

(iv) Calculations of Crop Performance Indicators in chickpea crop in the study area

Economic Indicators	
Crop Efficiency	Actual Average Yield / Average Potential Yield *100
Net Returns (in Rs.)	Total Returns-Total Cost
Benefit Cost Ratio	Total Benefits / Total Cost
Social equity indicators	
Equity in Distribution of Work	Number of women working hrs./total working hrs.*100
	Number of men working hrs./total working hrs.*100
Equity in Distribution of Income	Total women wage payment / total wage payments to human labour*100
	Total men wage payment / Total wage payments to human labour*100
Peer Advice Network	Percentage of farmers having contacts with other peer farmers, relatives, input dealers, friends
Official Advice Network	Percentage of the farmers contacted by the officials (Agriculture, KVK, Extension officer)
Private Advice Network	Percentage of the farmers contacted by the private company employee(seed, fertilizer and pesticide companies)
Environmental indicators	
Efficiency of the seed use	Actual Use of Seed Rate in kgs / Recommended Seed Rate in kgs*100
Efficiency of fertilizer use	Actual Use of N fertilizers dosage in kgs / Recommended N fertilizer dosage in kgs*100
Efficiency of the organic manure use	Actual number of HHs using FYM / Total number of HHs *100
Share of Machinery Usage in crop cultivation	Number of working hrs. Of machinery to total labour working hrs.

Results and Discussion

Socio-Economic Profile of the Respondents in the Study Area

Out of total selected sample of 400, 200 respondents each selected from Mahabubnagar and Kurnool districts in Telangana and Andhra Pradesh states respectively. Around 42 percent of the sample belongs to OBC's followed by other category with 41.5 percent, scheduled caste (15.25%) and scheduled tribes (1.25%). The average family size is 4.36 in the study area .In total sample size, 92.25 percent are male respondents whereas 7.75 percent of the respondents are female respondents. About 92.75 percent of the sample respondents are doing own cultivation, 8 percent of the respondents are private employees followed by casual agricultural labour (4.75 % respondents), self-employment (2 %), government employee (2 %), casual non-agricultural labour (0.75 %) and tenants (0.25 %). More than 90 percent of the HHs actively

participate in MGNEREGA National employment guarantee programme irrespective of their farm holding size and financial status. In the total sample about 73.5% of the respondents are small and marginal farmers followed by medium (14.25%) and large (12.25%) farmers.

Determinants of Cultivation and Non-Cultivation of Chickpea Crop in the Study Area

In the study area, 90 percent of the farmers are cultivating chickpea crop year on year without crop rotation. In addition to that, chickpea is cultivated largely (i.e., 43.5%) on a small-scale as subsistence farming followed by the small, medium and large group farmers in the study area. The analysis of determining factors responsible for cultivation or not cultivation of the chickpea crop in the study carried out by adoption of binary logit Model to explores the socio-economic, institutional and spatial factors influencing the cultivation of the chickpea crop. Thus it helps to explore the degree and direction of relationship between dependent and independent variables for cultivation of chickpea crop at the household level .In this regression model, sixteen independent variables and one dependent variable with the option of either cultivating or not cultivating chickpea are considered.

The findings of the analysis explain that, overall, the model correctly predicted 73.25 percent of the variation in the adoption behaviour of the farmers for chickpea cultivation in study area. Among the selected sixteen variables, only six variables namely livestock holding, age of the respondent, number of years of formal education, shortage of the labour, profitability with low risk, increased land leasing rates positively influenced chickpea cultivation. Out of these six variables, only two variables, namely shortage of the labour and profitability with low risk are statistically significant at 1 percent level of significance. And the other ten selected variables have a negative relationship and have influence on the cultivation of chickpea crop in the study area. Only three of these variables such as access to market, support from the financial institutes, and support from the extension division are statistically significant. The estimated result implies that for every one unit change in shortage of the labour the log odds increases by 1.44 percent or odds ratio of chickpea cultivation increases by 1.774 times as the chickpea is a low labour intensive crop and also there is wide scope for farm mechanization in chickpea cultivation. And for every unit of change of profitability the odds ratio of chickpea cultivation increases 1.82 times. The variables such as increased access to markets , increased support from the financial institutes and extension department by one unit change may result in a decline in chickpea cultivation by 0.9, 1.2 and 1.077 times respectively in the study area. This implies that increased Institutional support may result in the crop shift from chickpea crop to other competing crops on increased awareness and availability of information on the available crop technologies, marketing and price information of the other competing crops in the study area. The above analysis clearly shows that the variables shortage of

labour and crop profitability are statistically significant and positively influence chickpea cultivation in the study area whereas improved access to markets and increased support from financial institutions and extension departments may lead to crop shift and decline in chickpea cultivation in the study area.

Table-1 Determinants of cultivation of chickpea crop in study area-2015- 16

Sl.No	Variables	Co efficient	Odds ratio	Significance
0	Constant	4.452(1.910)		0.02
1	Land holding in acres	-0.004(0.037)		0.919
2	Gender of the respondent	-0.267(0.945)		0.778
3	Livestock holding	0.190(0.442)		0.668
4	Age of the respondent	0.011(0.022)		0.618
5	Number of years of formal education	0.001(0.043)		0.984
6	Number of years of chickpea faming	-0.066(0.026)		0.822
7	Shortage of the labour	1.445(0.447)	1.774	0.001*
8	Profitability	1.775(0.47)	1.82	0.000*
9	Increased Land leasing rates	0.95(0.797)		0.232
10	Suitability of the soil	-0.652(0.447)		0.145
11	Drought situation	-0.228(0.425)		0.591
12	access to market	-4.047(0.733)	-0.9	0.000*
13	Financial Institutional support	-1.127(0.646)	1.2	0.081***
14	Support from extension Institutions	-1.513(0.880)	1.077	0.086***
15	Support from private employee	-0.985(0.892)		0.269
16	Reasonable price for output	20.709(2562.93)		0.994

Note: 1. Figures in parenthesis indicates standard error

2. * indicate 1percent level of significance;** 5 percent level of significance; ** *10 percent level of significance

3. Odds ratio= e^{a+bxi}

Estimation of Chickpea Farms Production Efficiency

To estimate the chickpea farm efficiencies empirically, stochastic frontier production and cost function adopted. The empirical results of the stochastic production function reveals that, the selected independent variables fertilizer use, human labour and machine labour are

statistically significant at 5 percent level of significance except the seed variable in the production function. The variables human labour and machine labour have a positive relationship with output, suggesting that an increase in these variables would result in an increase in output level. The variables human labour (X3) and machine labour (X4) coefficients in the production function indicate that one unit change in these variables shows a 288 percent and 200.9 percent increase in output level respectively. However, the variable fertilizer (X2) coefficient is negative i.e., -0.77, implying the law of diminishing returns in production that an increase in fertilizer application will increase the output level up to some point , but will have negative effect beyond that. This infers that chickpea crop output declines by 77 percent for every one kg increase in fertilizer. As chickpea crop is a leguminous crop the demand for fertilizers would be less compared to other crops. The analysis of farm efficiency explains that, 99.77 per cent of the (total variation) difference between actual and potential output is due to the technical inefficiency of the farms.

Table-2 Maximum likelihood estimates of the parameters of stochastic frontier production function

Variables	Frontier production function(normal/half normal)	
	coefficient	P>|z|
Constant	-5.736711 (3.21571)	0.074
Seed (X1)	-0.1860077 (0.5108658)	0.716
Fertilizer(X2)	-0.7799696 (0.287791)	0.007*
Human labour (X3)	2.880122 (0.8064561)	0.000*
Machine labour (X4)	2.009363 (0.6170918)	0.001*
σu	4.687589 (0.1925836)	
σv	0.2202013 (0.057338)	
Υ	0.997798	
Lambda	21.28775 (0.2063823)	
Log likelihood	-735.7472	
R^2		
Number of observations	320	
Prob > chi^2	0.0025	

Note: 1. Figures in parenthesis indicates standard error
2. * indicate 5 percent level of statistical significance

Estimation of Economic efficiency of chickpea cultivating farms

For assessing the economic efficiency of the selected chickpea farms in the study area, stochastic frontier cost function was used. The constant term which was 5.74 was significant at 1 per cent level of risk. This is because the expenses on fixed factors of production such as land, farm machinery and tools etc. would continue to be incurred whether production takes place or not. The coefficients of all the factors included in the function were positive implying that an increase in the use of any of the factors will increase the total cost of production. The coefficients of the seed cost (0.05), fertilizer cost (0.37), human labour cost (0.17) and machine labour cost (0.22) were positive and each was significant at 5 percent significance level. This implies that one unit increase in these selected individual input cost by keeping other variables at constant may result in 5percent , 37percent , 17percent and 22percent rise respectively in cost of production of chickpea in the selected sample. The gamma coefficient 0.8778 was also significant at 1 percent. Here the implication of the value of gamma is that 87.78 per cent of the total variation in production cost is due to the economic inefficiency of the selected farms. Cost function analysis explains that, variables seed, fertilizer, human and machinery labour have direct relationship with cost of production of chickpea in the selected sample.

Table-3 Maximum likelihood estimates of the parameters of stochastic frontier cost function.

Variables	**Frontier production function (normal / half normal)**	
	Coefficient	Significance
Constant	5.740 (0.809)	0.000*
Out put	.0189 (0.001)	0.000*
Seed cost per kg	0.0515 (0.039)	0.193
Fertilizer cost per kg	0.3737 (0.225)	0.098**
Human labour wage per man day	0.171 (0.044)	0.000*
Machinery labour wage per hr	0.226 (0.050)	0.000*
σu	0.054 (0.008)	
σv	0.147 (0.013)	
Υ	0.87	
Lambda	2.680 (0.019)	
Log likelihood	279.86	
R^2	87.89	

Number of observations	320	
Prob > chi^2	0.00	

Source Primary survey 2015-16

Note: 1. Figures in parenthesis indicates standard error

2. ** indicate 1 percent * indicate 5 percent level of significance.

Estimation of TE, AE and EE of Chickpea Farms

On an average, farmers were able to obtain only 27.43 percent, 89.12 percent and 24.98 percent technical, allocative and economic efficiency respectively in the study area. Larger farms are more technically and economically efficient by 34.73 percent and 30.84 percent respectively than the other farming groups. Highest allocative efficiency is noticed in the case of marginal farms at 90.1 percent which indicates the efficient use of the inputs in the production process. The landholding size shows an inverse relationship with the cost of production of chickpea. i.e., as the landholding increases the cost of production is gradually declining. This lower cost of production in small land holding is due to restricted use of the required inputs and lack of practice of the sustainable management practices. The average technical efficient farmers require 42.24 percent cost saving to attain the status of the most efficient crop farmer i.e. {(1-0.2743/0.4749)} 100 ,while the lowest performing farmers would need 76.41 percent cost saving to become the most efficient farmer i.e. {(1-0.112/0.4748)} 100.

Table-4 Estimation of Technical, Allocative and Economic efficiency in chickpea crop across different categories of the farmers

Land holding size	Technical Efficiency	Allocative Efficiency	Economic Efficiency	Cost of Production per quintal(Rs)
Marginal	0.24	0.90	0.22	10258.92
Small	0.28	0.88	0.26	8996.10
Medium	0.26	0.88	0.23	7635.51
Large	0.34	0.87	0.30	5319.48
Total	0.27	0.89	0.24	8905.86

Estimation of the Crop Performance Indices in Chickpea Crop

Farm level three dimensional crop performance indicators are constructed to evaluate the performance of the chickpea crop i.e., economically ,socially and environmentally in the selected study region, as these crop performance indices are the most important indicators to know the impact and sustainability of the existing crop technologies in contemporary farming.

The calculation of three dimensional(socio-economic and environmental) crop performance indicators in case of chickpea farmers infers that, the average crop efficiency achieved in chickpea crop is in the range of 30-60 percent across the different land holdings in the study area. Crop efficiency has a direct relationship with the land holding size in the study area. The main reason attributed for low crop efficiencies are rainfed cultivation, poor irrigation and low input use. Chickpea cultivation is more profitable on medium and large farm holdings than the marginal and small landholdings. The marginal and small farmers are incurring negative net returns while the medium and large farmers are able to get good average net returns. This confirms that the economies of scale increase with an increase in the size of the landholding.

Table-5 Farm level crop performance Indices in chickpea crop

Particular		Marginal	Small	Medium	Large
Economic Indicators					
Crop Efficiency of chickpea crop (in %)		31.37 (-5.5)	42.10 (-4.6)	51.22 (-3.9)	62.44 (-3)
Benefit cost Ratio		0.72	0.96	1.08	1.43
Net Returns (in Rs)		- 4377.84	-704.43	1336.62	7689.67
Social dimension					
Work distribution in chickpea cultivation	Female	164.57	162.97	186.00	163.00
	Male	35.28	23.53	29.75	22.80
Distribution of wage payment to human labour (in Rs.)*	Male	3151.79 (47.33)	3171.61 (47.33)	3452.68 (48.66)	3386.2 (47.7)
	Female	3507.01 (52.67)	3529.60 (52.67)	3642.80 (51.34)	3710.5 (52.3)
Social capital and social network strength (in %)	Peer farmers	44.80	50.00	43.40	42.00
	Formal sources	30.40	23.75	30.19	32.00
	Private sources	24.80	26.25	26.42	26.00
Environmental dimension					
Efficiency of fertilizer use (Ratio)	Nitrogen	2.32	2.32	2.07	2.29
	Phosphorous	2.28	2.22	2.07	2.22
Efficiency of improved seed (Ratio)	JG-11 variety	1.12	1.14	1.12	1.06
Organic manure use by farmers (in %)	Goat manure	31.21	34.74	36.36	50.00
Efficiency of Machinery use in hrs #		7.29 (61.15)	9.48 (91.9)	11.92 (97.04)	11.95 (97.04)

Note: * Figures in parenthesis are share of female and male labour cost to total labour cost (in percentages)

Figures in parentheses indicate the percentage share of HHs in particular category

@Figures in the parenthesis are yield gaps in quintals per acre.

The social indicators explain that, gender equity in the work and income distribution in chickpea cultivation is present in the study area. The number of working hours for women is 4-5 times more than men's working hours in chickpea farming irrespective of the land holding. On an average, women work for 160 -180 hours per acre in chickpea cultivation during a season. On the other hand, men work for less than 30 hours including all the operations. In total human labour cost, wages paid to women labour is marginally higher than the men despite of their higher working hours across the different farm holding sizes. And another social indicator infers that, the peer advice network is stronger compared to the informal and formal advice group in dissemination of crop technologies information in the study area.

An environmental crop performance indicators witnesses that, irrespective of the land holding size, all the farmers are using unbalanced and excess fertilizers (N and P only) more than 2

times than the recommended quantity. The efficiency in the use of improved seed rate is almost the same on par to the recommended seed rate with marginal differences but the only concern is quality of the seed. On an average only 30-35 percent of marginal, small and medium farmers and 50 percent of the selected large farm HHS applied organic manure in their chickpea farms in the study area. The number of machinery working hours increasing as the land holding size increases. On an average, the marginal farmers are using for 7.29 hours, small farmers for 9.48hours, and medium farmers for 11.92hours and large farmers for 11.95hourrs in chickpea crop cultivation in the study area without practising the sustainable management practices.

Conclusion

Finally we can conclude that, the performance of the chickpea crop has been impressive with a positive growth rate in area, production and productivity in the selected sample. But, the farm level analysis reveals that the intensive cultivation of chickpea crop by using inputs disproportionately without practicing the sustainable management practices, constant mono cropping and failure to provide protected irrigation are few factors that resulted in significant yield variation across the different land holdings. The poor practice of sustainable management practices and poor institutional support for chickpea cultivation resulted in the lower technical and economic efficiency of the chickpea farms in the study area. Thus resulted in, lower yield levels and increased cost of cultivation and lower or negative net returns to the chickpea farmers particularly to small and marginal farmers. Chickpea cultivation is profitable in medium and large land holdings compared to small and marginal farm holdings because of increased economies of scale.

Suggestions and Policy Implications

- Efficient seed supply models and seed banks need to be developed for in-time supply of good quality seed to farmers at affordable cost.

- Institutional involvements (both public and private) and formal networking system need to be strengthened for bringing awareness on available improved technologies by providing the hands on information to the farmers for realizing the potential yields and crop income from chickpea.

- There is a need for policy measures for integrated use of organic manure such as vermicompost with the inorganic fertilizers. The action may replace the excess use of the chemical fertilizers use in chickpea crop cultivation and also results in achieving the higher yields.

- There is a need to mapping out a long-term strategy for agricultural technology adaptation, improving the irrigation system in rain-fed regions and at the same time policy must have flexibility to respond to changing climatic conditions change such as severe drought, rising temperatures, un timely rainfall etc.,

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