Farm profitability and Labour Use Efficiency

Reddy Amarender A

International Crops Research Institute for Semi-Arid Tropics, Hyderabad, Indian AGricultural Research Institute, New Delhi

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A Amarender Reddy

International Crops Research Institute for Semi-Arid Tropics, Patancheru-502324, Andhra Pradesh, India
Email: anugu.amarender.reddy@gmail.com

Extended Summary: *Appropriate choice of cropping systems to local agro-ecology increases profitability and employment. The increased labour shortage and redced profitability are growing concerns to the farmers. Keeping this, the paper written with the following objectives: i) To assess the profitability among different cropping systems in the semi-arid tropics; ii) To assess the labour use pattern among different cropping systems and farm size; iii) To determine the resource use efficiency of the different cropping systems in the SAT India; and finally iv) To assess the influence of regional/local factors on incomes of farmers in the SAT India. The study used plot wise data collected from 16 villages from four states namely Andhra Pradesh, Karnataka, Maharashtra and Gujarat for the crop year 2010 for an in-depth analysis of the profitability and labour use among different cropping systems in semi-arid tropics of India. And it also estimated the resource use efficiency especially labour across different farm size groups in the SAT India and finally to assess the influence of regional/local factors on profitability of farmers. The study shows that input intensive cropping systems like cotton, paddy, wheat, fruits and vegetables based cropping systems are more profitable across many of the SAT villages compared to coarse cereals, pulses and oilseeds based cropping systems. Moreover, the area under these cropping systems is increased in the dry lands due to the introduction of Bt cotton varieties, short duration varieties, price incentives and subsidies. Although pulses based cropping systems remain attractive due to higher prices and less labour requirement, needs to provide incentives to increase area given its environmental benefits in enriching the soil. Most of the villages are experiencing the shortage of labour as indicated by higher marginal productivity of labour and increasing trend of mechanisation. Farm size is having positive association with the hired labour use and farm mechanisation, but having negative association with family labour. Female employment has inverted "U" shape relation with farm size. This indicates that the farms with more than five hectares of land are detrimental to women employment as farm mechanization in large farms replaces women labour.*

Female labour use per hectare is higher in cotton, coarse cereal, paddy and wheat based cropping systems. While pulses and oilseed based cropping systems are using less female labour. In case of male labour use per hectare, horticultural crops followed by coarse cereals, cereal mixed were ranked high, while pulses and oilseed based cropping systems were using less labour. Many studies pointing out the feminization of agriculture. Female to male labour ratio (an indicator for feminization of agriculture) was higher in cotton, coarse cereal, cereal-mixed, paddy and wheat based cropping systems, while lower in pulses and oilseed based cropping systems. Overall, human labour use is higher for cotton, paddy and wheat and horticultural crop based systems, but less in pulses and oilseed based cropping systems. Farm mechanization is higher in paddy and wheat based cropping systems, while lower in horticultural and coarse cereal based cropping systems. Overall cotton, paddy and wheat based cropping systems are labour intensive, while oilseed based cropping systems are less labour intensive crops. Feminisation of agriculture is more wide spread in cotton based cropping systems as it requires more labour for picking of cotton which is entirely done by women and also in paddy where transplanting entirely done by women.

There is a debate on the use of hired labour in agriculture. The ratio between hired labour to family labour increased for both male and female as plot size increases, indicating strong positive relation between hired labour and plot size. The ratio of hired labour to family labour is higher among female across all the land size categories. This indicates the consolidation of land will increase demand for hired labour particularly for women in the process of commercialization of agriculture. And the recent phenomenon of reverse tenancy (leasing in of land by large land owners from the small and marginal landholders) will also increase the demand for hired labour both for men and women.

There are many studies which dealt with the relationship between farm size and profitability. But very few studies are dealt with farm size and labour use. Feminization is defined as ratio of female to male labour days. The relationship is inverted "U" shape, indicating up to certain farm size the female labour is increased, then after as farm size increases the female labour use decreased. This is in line with many findings on feminisation of agriculture. It indicates that the farm mechanization in farms with more than 5 hectare will displace female labour compared to male labour on the farm activities. Hence, results show that the corporate farming and contract farming, where the possibility of farm size increases beyond

5 hectare will have adverse effect on women employment in agriculture, which have important socio-economic consequences.

The results indicates that the one hectare increase in plot size may lead to 0.5 mandays decrease and Rs.44.1 increase in expenses in farm mechanization. It shows clear inverse relationship between plot size and human labour use, while there is a positive relation between plot size and machine labour use. The marginal productivity of labour is Rs.496/day, whereas the ongoing wage rate is only about Rs.150-200., which indicates huge shortage of labour in the study villages. The marginal returns to human labour hour is higher in Karnataka (Rs.96/hour) followed by Gujarat (Rs. 65/hour), Andhra Pradesh (Rs.62/hour) and Maharashtra (Rs.33/hour). This indicates that there is higher shortage of labour in Karnataka villages followed by Gujarat, Andhra Pradesh and Maharashtra. Marginal returns on machine labour cost is higher in Maharashtra villages (Rs.1.9/each rupee spent) among all the villages.

Keywords: *Cropping systems, semi-arid tropics, cost-benefit analysis, production function, labour use efficiency*

Introduction

In the last decade new varieties and many other technological advances are available for wider adoption by farmers, most noticeable are Bt cotton varieties, hybrid rice, pest and disease resistant and short duration varieties of pulses and oilseeds which helped in shift in cropping systems to enhancing profitability and employment in the farm sector. Semi-arid tropics are particularly benefited through these technological changes in the dryland farming systems mainly through adoption of short duration varieties, pest and disease resistant varieties like Bt cotton, drought tolerant varieties. For example the area under new crops like BT cotton, soybean and chickpeas are increasing exponentially in drylands of SAT India. The changing rural socio-economic conditions, shortage of labour, higher wage rates and adoption of farm machinery are also having significant influence on the choice of cropping pattern. The wider availability of subsidised inputs like free electricity for irrigation, subsidised distribution of high-yielding variety (HYVs) seeds, modern agricultural equipment, fertilizers, pesticides, etc are also influenced wider adoption of input intensive paddy, wheat and cotton based cropping systems. In most of the villages, there is increasing trend of higher wage rates, shortage of male workers to out-migration, feminisation of agriculture which also have impact on choice of cropping systems for less labour intensive crops like pulses and oilseeds and horticultural crops (Birthal et al., 2013). However, the "level" of productivity impact in the successive generations of modern technologies (such as HYVs) has apparently been going down. However, many of the past studies are indicated that dryland crops are not benefited as that of irrigated crops in semi-arid tropics in India (Tripp and Pal, 2001). Some of the other findings also show that the technology for dryland cropping systems mostly dominated by pulse crops, oilseeds and coarse cereals in SAT region are not proven to be highly profitable, although they reduced risk considerably (Reddy, 2009). However, recently some other studies on Bt cotton shows that it benefited many dryland farmers through increase in profitability and employment opportunities for the poor agricultural labourer. The first genetically modified (GM) cotton introduced in 2002 in the country has transformed the landscape of the Indian cotton scenario (Ramasundaram *et al.,* 2011). The evidence shows that Bt cotton is scale neutral and profitable to all groups of farmers. Single crop based studies are not able to capture the impacts of the adoption of new technology on farmers income and employment, hence in this study, the impact of adoption of new technology and cropping systems on farm profitability and labour use has studied with the following major objectives: i) To assess the profitability among different cropping systems in the semi-arid tropics; ii) To assess the labour use pattern among different cropping systems and farm size; iii) To determine the resource use efficiency of the different cropping systems in the SAT India; and finally iv) To assess the influence of regional/local factors on incomes of farmers in the SAT India.

Data and Methodology

The data used in this paper is obtained from the project Village Dynamic Studies in South Asia (VDSA) in which ICRISAT collected a range of data from households engaged farm activities in 16 villages in India for the period 2010 crop year. The sixteen villages in the VLS studies of ICRISAT were selected from four states (Andhra Pradesh, Maharashtra, Gujarat and Karnataka), which represents the broad agro climatic sub regions in the semi-arid tropics of India. The study villages are Aurepalle, Babrol, Chata, Kappanimbargi, Kanzara, J.C Agraharam, Pamidipadu, Markabbinhalli, Shirapur, Kinkheda, Makhiyala, Kalman, Tharati, Markabbinhalli, Belladamadugu,Karamdichingariya (Figure 1). We have used plot level data of the sample farmers to know the profitability, labour use pattern and resource use efficiency.

We have tested the data with various production functional forms by using both frontier production and ordinary least squares techniques. We have chosen Cobb-Douglas production function generated from OLS method, keeping the high adjusted R^2 and theoretically right signs. The data rejected the frontier functional form. The variables included in the model are given in Table 1. We have omitted some of the variables which showed strong multicollinearity problem. The coefficients directly indicate the elasticity of production (% change in dependent variable (gross returns) due to 1% change in independent variable. The marginal effects (change in dependent variable due to one unit change in independent variable) of inputs and dummy variables are estimated by using standard methods (Mundlak et al., 2012). The interpretation of coefficients of dummy variables is adopted from Mundlal et al., 2012. Which indicated that if b is the estimated coefficient on a dummy variable and V(b) is the estimated variance of b then g = 100 (exp(b - V(b)/2) - 1) gives an estimate of the percentage impact of the dummy variable on the dependent variable.

The general functional form is

$$y = a \times x_1^{b_1} \times x_2^{b_2} \times \ldots\ldots\ldots\ldots . x_n^{b_n}$$

On linearization, the translog modified production function model becomes

$$\log(y) = \log(a) + b_1 logx_1 + b_2 logx_2 + b_3 logx_3 + b_4 logx_4 + b_5 logx_5 + b_6 logx_6 + b_7 logx_7 + b_8 logx_8 + b_9 LSdx_9 + \sum_{i=1}^{n} CS_i + \sum_{j=1}^{m} S_j + \sum_{k=1}^{l} V_k + U_l \ldots\ldots\ldots\ldots\ldots\ldots Eq(1)$$

Figure 1: Map showing location of the selected villages in SAT India

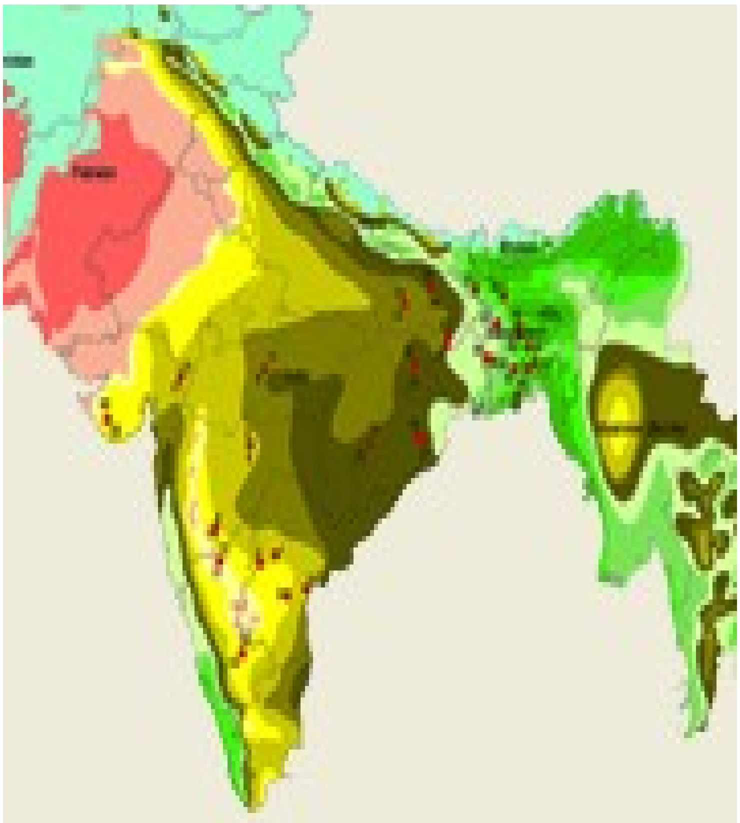


Table 1: Descriptive variables used in the Cobb-Douglas production function model

Determinants	Cropping System Dummy=0,1)$\sum_{i=1}^{n} CS_i$	Season Dummy=0,1)$\sum_{j=1}^{m} S_j$	Village Dummy=0,1)$\sum_{k=1}^{l} V_k$
Area (in ha). (x_1)	Cereals (Control)	Khariff (Control)	Aurepalle (Control)
Seed cost/plot. (x_2)	Cereal Mixed	Rabi	Babrol
Fertiliser Cost/plot.(x_3)	Pulses	Summer	Belladamadugu
Man day in hours/plot(x_4)	Pulses+Mixed	Annual	Chatha
Bullock day in hours/plot(x_5)	Oilseeds	Perennial	Dokur
Machinery cost in Rs.(x_6)	Rice,Wheat	Mixed	J.C Agraharam
Land Rent in Rs./ha (x_7)	Cotton		Kalman
Other cost/plot.(x_8)	Others		Kanzara
Land Status (Own=1,Rent=0) (x_9)			Kappanimbargi
			Karamdichingariy
			Kinkheda
			Makhiyala
			Markabbinhalli
			Pamidipadu
			Shirapur
			Tharati

Note: Dependent Variable: log(Total Gross Revenue/plot.)

Results and discussions

The dominant cropping systems in each selected village in SAT villages were presented in table 2. Paddy based cropping systems are still dominated in Telangana region of Andhra Pradesh villages namely in Dokur and Aurepalli. Area under the cotton is higher in Aurepalle, while area under pigeonpea is higher in Dokur village. In coastal Andhra village J.C. Agraharam oilseed based cropping system (sunflower) is dominant followed by chickpea and cotton. In Pamidipadu (another coastal Andhra village) major cropping systems are pulse based mostly dominated by chickpea. It indicates that the area under traditional dry land crops like pearl millet and sorghum is not significant in these villages. The two Maharashtra villages (Kinkheda and Kanzara) are dominated by wheat, soybean and cotton based cropping systems, and another village Shirapur is dominated by sugarcane based cropping system, while Kalman is dominated by sorghum and pigeonpea. It clearly shows that Maharashtra villages are much forward in terms of cropping systems with commercial crops like sugarcane, cotton and soybean. Karnataka village Belladamadugu is dominated by paddy and finger millet based cropping systems. Kappanimbargi village is dominated by wheat, maize, pigeonpea and sorghum based cropping systems. Markabbinhalli is dominated by pigeonpea and chickpea based cropping systems. Tharati village is commanded by crysanthemum and finger millet+pigeonpea. It shows that the Karnataka villages are dominated by a mixture of traditional sorghum, millets and also pulse crops like chickpea and pigeonpea and to some extent some commercial crops like chrysanthemum and other horticultural crops. Gujarat villages Babrol and Chata are dominated by maize and paddy based cropping systems. While other two villages of Gujarat (Karamdichingariya and Makhiyala) are dominated by groundnut and wheat based cropping systems. The above figures indicates that the cropping systems are diverse in SAT villages, but mostly dominated by coarse cereals and legume crops (both oilseeds and pulses) and also some advanced villages like Kanzara and Kinkheda are dominated by commercial crops like cotton and sugarcane. The area under paddy and wheat based cropping systems are also higher.

Table 2: Top five dominant cropping systems in the sample villages in 2010

Andhra Pradesh			
Aurepalle	**J.C Agraharam**	**Dokur**	**Pamidipadu**
Paddy (65)	Sunflower (34)	Paddy(56)	Chickpea(25)
Cotton (46)	Pigeonpea (15)	Pigeonpea(11)	Sesamum(21)
Sorghum +pigeonpea(20)	Chickpea (15)	Groundnut(6)	Jowar fodder(16)
Cotton+pigeonpea(15)	Paddy(9)	Castor(3)	Blackgram(15)
Pigeonpea(14)	Cotton(bt) (7)	Castor+pigeonpea(2)	Sorghum fodder(8)
Gujarat			
Babrol	**Chatha**	**Karamdichingariya**	**Makhiyala**
Maize(47)	Maize(35)	Groundnut(52)	Groundnut(36)
Paddy(31)	Paddy(29)	Wheat(28)	Wheat(9)
Maize +pigeonpea(25)	Maize +pigeonpea(26)	Pearlmillet(17)	Cotton(9)
Chickpea(21)	Blackgram(20)	Chickpea(5)	Coriander(8)
Wheat(9)	Pigeonpea(2)	Sorghum(5)	Sesamum(6)
Karnataka			
Belladamadugu	**Kappanimbargi**	**Markabbinhalli**	**Tharati**
Paddy(20)	Wheat(19)	Pigeonpea(34)	Crysanthemum(21)
Ragi(16)	Maize(18)	Chickpea(21)	Ragi+pigeonpea(10)
Groundnut(9)	Pigeonpea(18)	Cotton(12)	Arecanut(8)
Groundnut +pigeonpea +cowpea+ horsegram(6)	Sorghum(17)	Sorghum(9)	Paddy(7)
Maize fodder(4)	Cotton(15)	Wheat(8)	Ragi(7)
Maharashtra			
Kinkheda	**Kanzara**	**Shirapur**	**Kalman**
Wheat(38)	Soybean+pigeonpea(56)	Sugarcane(129)	Sorghum(72)
Soybean+pigeonpea(26)	Wheat(38)	Seasonal fallow(91)	Seasonal fallow(70)
Soybean(14)	Sorghum(15)	Sorghum(37)	Pigeonpea(47)
Cotton(bt) +greengram+pigeonpea(9)	Cotton+greengram+ pigeonpea(14)	Sorghum fodder(23)	Onion(16)
Cotton+pigeonpea(6)	Soybean(14)	Wheat(17)	Chickpea(11)

Source: ICRISAT, VLS (2010) Note: Figures in parentheses are indicates no. of plots

Profitability

Season wise profitability of different cropping systems is given in Table 3. Kharif season reported lowest returns (Rs.23008/ha) followed by *rabi* (Rs.25816/ha), *summer* (Rs.42875/ha), annual (Rs.53866/ha), perennial (Rs.100210)/ha and the highest returns were observed in double or triple cropping systems (Rs.174739/ha). On an average net returns are Rs.32427/ha for the pooled sample of all the villages. It indicates that increase in area in *rabi* season wherever feasible will increase net returns to farmers with the provision of irrigation facilities. The perennial and annual crops are also fetching higher returns. Creating irrigation facilities are important to increase area under double cropping systems, perennial crops (like horticultural crops), annual and summer crops. There will be high returns for increasing area under high technology solutions like sprinkler and drip irrigation systems, which will help in increasing area under irrigation.

Table 3: Season-wise net returns (Rs/ha) in SAT villages

Name of the Village	Season						
	Kharif	Rabi	Summer	Annual	Perennial	Kharif - Rabi	Total
Aurepalle	32814	22700	-	37920	44288	32431	31846
Babrol	21727	33028	-	51806	-	-	27171
Belladamadugu	5138	30078	-	-	-	53391	8769
Chatha	33092	70219	-	-	-	-	40232
Dokur	13989	32761	-	51519	-	-	22650
J.C Agraharam	9672	25199	-	79058	-	-17948	27812
Kalman	12532	15017	96406	-	86875	76790	15728
Kanzara	33958	34217	38655	-	-	-	34158
Kappanimbargi	7803	18113	32440	-	140806	369119	53473
Karamdichingariy	34483	34471	-	-	-	39588	34499
Kinkheda	18703	17118	-9278	-	-	5624	18144
Makhiyala	39683	64529	93480	-	-	-	51655
Markabbinhalli	21227	16338	-	-	-	-	18267
Pamidipadu	24193	51545	-	51371	-	30711	45931
Shirapur	3695	7237	3481	-	98450	12896	50712
Tharati	28233	289352	-11385	-	94450	104021	65095
Total	23008	25816	42875	53866	100210	174739	32427

Cropping system wise profitability

In Table 4 cropping system wise net returns were presented. The net returns per hectare is the highest among commercial crop based cropping systems (like sugarcane, fruits and vegetables etc.,) with Rs.60628/ha, followed by cotton based systems (Rs.40661/ha), oilseeds based cropping systems (Rs.32762/ha), rice or wheat based systems (Rs.25870/ha), cereal based mixed cropping systems (Rs.24870/ha), pulses-cereal mixed cropping system (Rs.24783/ha), pulses based cropping system (Rs.17504/ha), coarse cereals (Rs.13429/ha). There is higher net return from cultivation of high-value crops like fruits and vegetables, cotton, rice or wheat in the SAT villages, but to increase an area under these crops required technological solutions in terms of micro-irrigation, evolving short duration and drought tolerant varieties and irrigation facilities. For instance, area expansion of chickpea in Karnataka and Andhra Pradesh villages and soybean and cotton in Maharashtra and Andhra Pradesh villages are mainly through wider adoption of short duration, and disease and pest resistant varieties (Bt cotton).

Table 4: Village-wise and cropping system wise net returns (Rs/ha)

Name of the Village (State)	Cropping Systems								
	Cereals	Cereals Mixed	Pulses	Pulses + Mixed	Oilseeds	Rice or Wheat	Cotton	Other Commercial Crops	Total
Aurepalle	11727	-	-717	-	14701	25401	43802	68360	31846
Babrol	19101	21420	28303	-	-	41470	-	5921	27171
Belladamadugu	6751	-1919	326	-	5843	30147	-	39466	8769
Chatha	33428	41604	28336	-	-	55062	-	-	40232
Dokur	6525	-	-7116	-	20616	26867	11230	-	22650
J.C Agraharam	-	-	12383	-	26703	64656	79696	-4704	27812
Kalman	14865	27249	9526	-	8267	16094	-	19469	15728
Kanzara	9422	71222	33130	28335	13662	19721	50436	81042	34158
Kappanimbargi	10095	10205	14032	-	6346	24886	31879	244757	53473
Karamdichingariy	31970	-	47336	-	38261	20806	45763	20955	34499
Kinkheda	8127	26321	23007	17453	-	10744	22047	207	18144
Makhiyala	16986	-	12803	-	57530	43390	46218	32896	51655
Markabbinhalli	10843	12467	19782	-	8810	11443	49743	15117	18267
Pamidipadu	14685	-	16968	-	55257	-	54602	86148	45931
Shirapur	8097	-	3229	-	1580	25447	-	56865	50712
Tharati	20928	20650	10814	-	12975	48817	-	146052	65095
Total	13429	24870	17504	24783	32762	25870	40661	60628	32427

Labour use

Table 5 depicts cropping system wise farm size and labour use. Average plot area is higher in oilseed based cropping systems, followed by pulses based cropping systems, cotton based cropping systems, and the least plot size was observed among coarse cereal based cropping systems. % irrigated area is higher among paddy and wheat based cropping systems, followed by horticultural crops, oilseed based cropping systems and the least irrigated area is observed in cotton based and cereal mixed cropping systems. Gender wise labour is also presented in the table. Female labour use per hectare is higher in cotton, coarse cereal, paddy and wheat based cropping systems. While pulses and oilseed based cropping systems are using less female labour. In case of male labour use per hectare, horticultural crops followed by coarse cereals, cereal mixed were ranked high, while pulses and oilseed based cropping systems were using less labour. Many studies pointing out the feminization of agriculture (Vepa, 2005; Arun, 2012). Female to male labour ratio (an indicator for feminization of agriculture) was higher in cotton, coarse cereal, cereal-mixed, paddy and wheat based cropping systems, while lower in pulses and oilseed based cropping systems. Overall, human labour use is higher for cotton, paddy and wheat and horticultural crop based systems, but less in pulses and oilseed based cropping systems. Farm mechanization is higher in paddy and wheat based cropping systems, while lower in horticultural and coarse cereal based cropping systems. Overall cotton, paddy and wheat based cropping systems are labour intensive, while oilseed based cropping systems are less labour intensive crops. Feminisation of agriculture is more wide spread in cotton based cropping systems as it requires more labour for picking of cotton which is entirely done by women and also in paddy where transplanting entirely done by women.

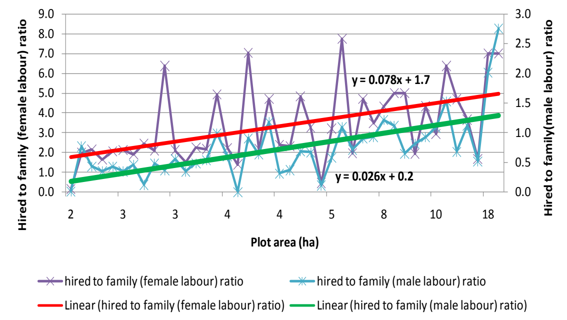
Table 5: Labour use per hectare among different cropping systems

Cropping system	Average plot area(ha)	% irrigated area	Female days/ha	Male days/ha	Female to male (%)	Standard days*/ha	Bullock days/ha	Machine value Rs./ha
Coarse cereals	1.2	39(4)	53(2)	33(3)	158(2)	70(4)	8(2)	2578(7)
cereal mixed	1.3	24(6)	45(5)	31(5)	147(3)	62(5)	7(3)	2948(5)
Pulses	2.3	31(5)	29(7)	23(7)	126(5)	43(7)	4(5)	3132(4)
Pulses mixed	2.2	23(7)	35(6)	32(4)	110(7)	57(6)	7(3)	3882(2)
Oilseed	3.5	40(3)	20(8)	23(7)	86(8)	37(8)	3(6)	3710(3)
Paddy and wheat	1.4	56(1)	51(3)	39(2)	130(4)	74(2)	6(4)	4668(1)
cotton	2.2	24(6)	72(1)	30(6)	240(1)	80(1)	10(1)	2732(6)
Others (horticultural)	1.9	51(2)	46(4)	41(1)	112(6)	73(3)	6(4)	2093(8)

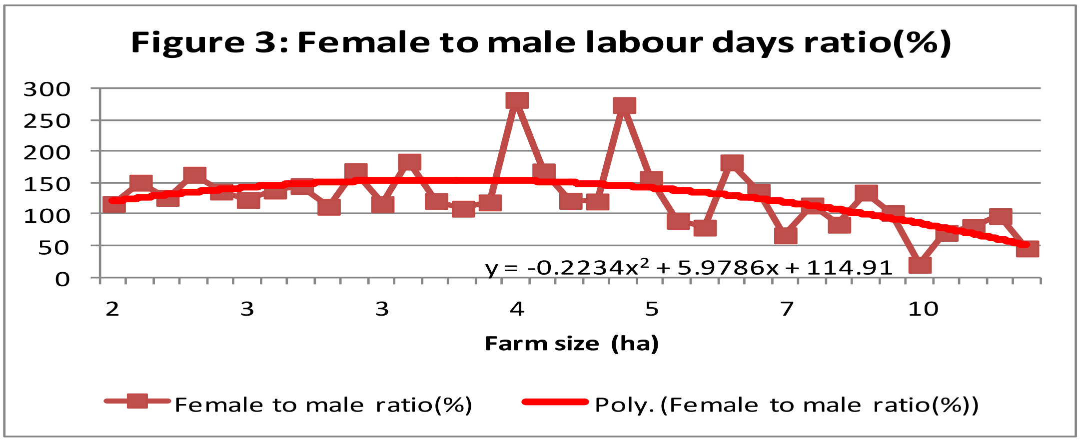
Note: the standard days are calculated as weighted average of 0.8*female labour days+male labour days.

There is a debate on the use of hired labour in agriculture. Figure 2 presents the ratio between hired labour to family labour for both male and female. It increased for both male and female as plot size increases, indicating strong positive relation between hired labour and plot size. The ratio of hired labour to family labour is higher among female across all the land size categories. This indicates the consolidation of land will increase demand for hired labour particularly for women in the process of commercialization of agriculture. And the recent phenomenon of reverse tenancy (leasing in of land by large land owners from the small and marginal landholders) will also increase the demand for hired labour both for men and women.

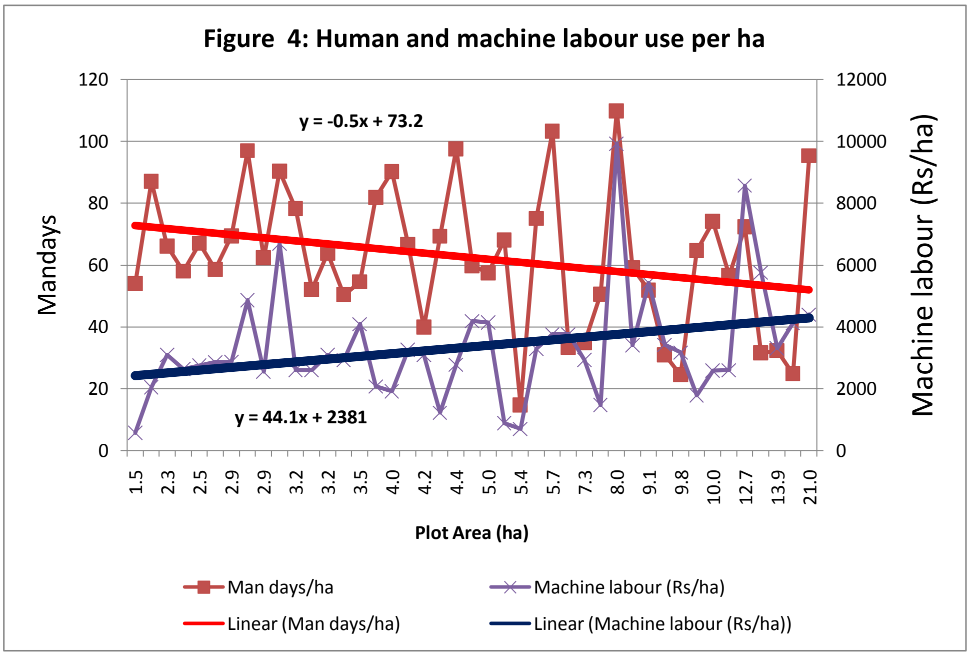
Figure 2: Plot size and hired to family labour ratio



There are many studies which dealt with the relationship between farm size and profitability (Reddy, 2011). But very few studies are dealt with farm size and labour use. Figure 3 depicts the relationship between farm size and feminization. Here feminization is defined as ratio of female to male labour days. The relationship is inverted "U" shape, indicating up to certain farm size the female labour is increased, then after as farm size increases the female labour use decreased. This is in line with many findings on feminisation of agriculture. It indicates that the farm mechanization in farms with more than 5 hectare will displace female labour compared to male labour on the farm activities. Hence, results show that the corporate farming and contract farming, where the possibility of farm size increases beyond 5 hectare will have adverse effect on women employment in agriculture, which have important socio-economic consequences.



The figure 4 depicts the relationship between plot size and human and machine labour use. It indicates that the one hectare increase in plot size may lead to 0.5 mandays decrease and Rs.44.1 increase in expenses in farm mechanization. It shows clear inverse relationship between plot size and human labour use, while there is a positive relation between plot size and machine labour use.



Results of pooled production function

Table 6 presents the pooled production function results for all the SAT villages with gross returns as dependent variable. The coefficient of determination adjusted (R^2) was 0.83 for this model. It indicates that the explanatory variables included in the model were explaining 83%

variation in the farm returns. The contribution of area, seed, fertiliser, human labour, machine labour and other costs in determining the return are significant at the 1% level of confidence and the contribution of machinery is statistically significant at 5 % level of confidence. The regression coefficients in the cob-douglass production function indicate the elasticies. The elasticities in table 6 indicates that with an additional use of 1% for each of area, seed, fertiliser, human labour, machine labour and other costs would lead to increase in gross revenue by 0.30%, 0.11%, 0.07%, 0.67%, 0.04% and 0.09% respectively. The contribution of different cropping systems is tested by including cropping systems dummies (with coarse cereals as comparison group). Pulses-mixed, major cereals (rice or wheat), cotton based cropping systems are statistically significant at 1 % level of significance. Pulses and other crops (mostly horticultural and commercial crops) are statistically significant at 5 % level of significance. The results indicates that the pulses based mixed cropping systems are most profitable followed by cotton based cropping systems, major cereals (rice or wheat), other commercial crops and pulses based crops compared to coarse cereals cropping systems. This indicates that the pulses based cropping are more profitable after discouting for the input use compared to coarse cereals. This may be attributed to low input intensive nature of pulse based cropping systems. It is also due to the recent increase in prices of pulse crops even though yields are less than other crops. Farmers are also getting more returns in cotton, paddy and wheat based cropping systems mainly driven by both higher output prices and also technological advances in increasing yields.

Table 6: Production Function Regression Results for overall SAT states

Explanatory Variables	β Coefficients	t-value	Marginal effects	Mean
Mean dependent variable (gross returns(Rs/plot)				33587
Constant	3.335	14.0		
Area (in ha).	0.75*	8.0	14765	0.688
Man day (hours/plot)	0.675*	15.6	62.04	365
Bullock day (hours/plot)	-0.046	-1.9	-51.58	30
Machinery cost (Rs./plot)	0.042**	2.1	0.63	2244
Seed cost (Rs/plot).	0.114*	4.8	2.04	1880
Fertiliser (Rs/plot)	0.073*	2.6	1.44	1708
Land Rent in (Rs./ha)	0.01	0.2	0.09	11493
Other cost in (Rs./plot)	0.092*	5.0	1.86	1660
Ownership Status (Own=1, Rent=0)	0.069	1.5	0.07	
Cropping System (Dummy=0,1 Control (Cereals))				
Pulses+Mixed	0.314*	3.2	0.37	
Cotton	0.291*	3.3	0.34	
Rice, wheat based	0.229*	2.9	0.26	
Others	0.208**	2.1	0.23	
Pulses	0.191**	2.4	0.21	
Oilseeds	0.033	0.4	0.03	
Cereal Mixed	0.019	0.2	0.02	
Season (Dummy=0,1 Control:Kharif)				
Perennial	0.163	1.2	0.18	
Annual	0.111	1.2	0.12	
Rabi	0.065	1.4	0.07	
Summer	-0.105	-1	-0.1	
Double cropping systems	-0.508	-4.4	-0.4	
Sample Size	1028			
Adjusted R-Square	0.827			

Note: * Significant at 1 per cent level ** Significant at 5 per cent level *** Significant at 10 per cent level; mean of gross returns is Rs. 33587/plot; Coefficients indicates the elasticities. The positive coefficient indicates independent variable influences the returns positively, negative coefficient indicate the independent variable influences negatively. Marginal effects indicate that the change in the gross returns due to one unit change in the independent variable. 15 regional dummies (with Aurepalle as reference category) included, but not presented to save space.

The table 6 also presents marginal effects, which indicates that the change in gross return per unit change in the explanatory variable included in the model. The marginal returns to one hectare of land were Rs. 14765 which is almost equivalent to the local rental value of land. Marginal returns to one standard hour of labour are Rs.62. This indicates that the marginal productivity of labour is Rs.496/day, whereas the ongoing wage rate is only about Rs.150-200., which indicates huge shortage of labour in the study villages. Marginal returns to seed and fertilizer are higher than the one for each rupee spend on them, indicating the less than optimal use of these inputs and need for increased spending on seed and fertilizers. In the previous section, pulse based mixed, cotton based, paddy and wheat based, other commercial crops based and pulse based cropping systems are significantly high in returns than the control coarse cereal based cropping systems to the extent of 37%, 34%, 26%, 23% and 21% respectively. It shows that farmers can reap higher returns through shifting their cropping systems. On the other hand the contribution of seasonal dummies is statistically insignificant, but the perennial, annual and rabi season crops are having significantly higher marginal effects which was also confirmed by the observation recorded during the focus group discussions and also with the existing literature. Interestingly, the impact of village dummies is statistically significant and the marginal effects also have higher absolute number. The results indicates that villages like Makhiyala, Chatha, Shirapur , JC Agraharam, Babrol, Tharati, Kalman, Karamdichingariy, Markabbinhalli, Kanzara and Kappanimbargi significantly have higher gross returns than the Aurepalle village plots to the extent of 163%, 154%, 109%, 75%, 73%, 67%, 60%, 53%, 50%, 45% and 33% respectively.

Results of state wise production function

In table 7, marginal returns to one ha of land is higher in Gujarat (Rs.28082/ha) followed by Andhra Pradesh (Rs.11762/ha), Maharashtra (Rs.11467/ha) and Karnataka (Rs.11365/ha). Marginal returns to expenses on seeds are higher in Karnataka (Rs.3) and Maharashtra (Rs2) per each rupee spends on seed. While marginal returns on fertilizers is higher in Maharashtra (Rs. 3.2 per each rupee spent). The marginal returns to human labour hour is higher in Karnataka (Rs.96/hour) followed by Gujarat (Rs. 65/hour), Andhra Pradesh (Rs.62/hour) and Maharashtra (Rs.33/hour). This indicates that there is higher shortage of labour in Karnataka villages followed by Gujarat, Andhra Pradesh and Maharashtra. Marginal returns on machine labour cost is higher in Maharashtra villages (Rs.1.9/each rupee spent) among all the villages. In Andhra Pradesh villages cotton based cropping system gave 80% more gross returns, while pulses based cropping systems gave 28% less returns than the coarse cereal based cropping systems. In Karnataka villages, oilseed cropping systems and cotton based cropping systems gave 47% and 43% less returns than coarse cereal crops as there are higher prices for sorghum during the study year. It is interesting to see that in Maharashtra, the estimated gross returns on all cropping systems namely cereal mixed, pulses, pulse mixed, oilseeds, paddy and wheat, cotton and other cropping systems are significantly higher by 72%, 95%, 86%, 90%, 67%, 82% and 120% respectively compared to coarse cereal crops in the study villages. In Gujarat villages, oilseeds, cotton and other commercial cropping systems have 48% and 108% higher gross returns, but other commercial crops have 36% lower gross returns than coarse cereal cropping systems. In Karnataka state villages, plots with summer crop show 46% less returns than kharif season crops. In Maharashtra villages, again returns of summer crop are 42% less than kharif crops. On the other hand in Gujarat villages summer and annual crops have significantly high returns to the extent of 60% and 51% respectively compared to kharif season coarse cereal crops. Overall, the state-wise regression results indicates that the profitability vary across the regions and villages among different cropping systems and needs location specific strategies for choosing cropping systems which maximize income and employment.

Table 7: SAT State-wise Production Function Regression Results

Explanatory Variables	Andhra Pradesh		Karnataka		Maharashtra		Gujarat	
	β	Marginal effect	β	Marginal effect	β	Marginal effect	β	Marginal effect
Mean dependent variable (gross returns/plot)		(32299)		(33995)		(33401)		(35124)
Constant	2.71*		3.95*		3.61*		6.42*	
Area (in ha).	0.52*	11762 (1.44)	0.65*	11365 (1.85)	0.65*	11467 (1.83)	1.45*	28082 (1.67)
Seed cost(Rs/plot).	-0.08	-1.4 (1877)	0.12***	3.0 (1296)	0.11*	2.0 (1735)	0.02	0.2 (2821)
Fertiliser (Rs/plot)	0.09	1.4 (2045)	-0.01	-0.2 (1730)	0.19	3.2 (1919)	-0.02	-0.8 (822)
Man day (hours/plot)	0.93*	62 (484)	0.99*	96 (333)	0.36*	33 (355)	0.57*	65 (283)
Bullock day (hours/plot)	0.03	37 (26)	-0.12**	-241 (16)	0.03	29 (33)	-0.13*	-98 (43)
Machinery cost (Rs./plot)	0.07	0.7 (3284)	0.04	0.7 (1950)	0.12*	1.9 (2034)	0.02	0.4 (1613)
Land Rent in (Rs./ha)	0.01	0.09 (7328)	0.01	0.09 (7690)	0.01	0.009 (14650)	0.001*	0.009 (13723)
Other cost in (Rs./plot)	0.07***	1.6 (7690)	0.01	0.1 (2619)	0.11*	3.0(1203)	0.04	0.7 (1893)
Ownership Status (Own=1, Rent=0)	0.03	0.03	-0.01	-0.01	0.15*	0.16	-	
Cropping System (Dummy=0,1 Control :Cereal based)								
Cereal Mixed	-		-0.28	-0.24	0.54*	0.72	0.00	
Pulses	-0.33**	-0.28	-0.30	-0.26	0.67*	0.95	0.16	0.17
Pulses + Mixed	-		-		0.62*	0.86	-	
Oilseeds	0.12	0.13	-0.63*	-0.47	0.64*	0.90	0.39**	0.48
Rice + Wheat	0.07	0.07	0.03	0.03	0.51*	0.67	0.14	0.15
Cotton	0.59*	0.80	-0.57**	-0.43	0.60*	0.82	0.73*	1.08
Others	0.10	0.11	-0.29	-0.25	0.79*	1.20	-0.44*	-0.36
Season (Dummy=0,1 Control: Kharif)								
Rabi	0.32*	0.38	-0.03	-0.03	-0.04	-0.04	0.09	0.09
Summer	-		-0.62**	-0.46	-0.55*	-0.42	0.47*	0.60
Annual	0.08	0.08	-		-		0.41*	0.51
Perennial	-		0.05	0.05	0.13	0.14	-	
Double	-0.09	-0.09	-1.11*	-0.67	-0.28	-0.24	-	
Adjusted R-Square	0.88		0.79		0.80		0.93	
Sample Size	246		164		375		243	

Note: * Significant at 1 per cent level ** Significant at 5 per cent level *** Significant at 10 per cent level, figures in parentheses are means of the variables. Coefficients indicate the elasticities. Positive coefficient indicates independent variable influences the returns positively, negative coefficient indicate the independent variable influences negatively. Marginal effects indicate that the change in the gross returns due to one unit change in the independent variable. 15 regional dummies (with Aurepalle as reference category) included, but not presented to save space.

Conclusion

The paper examined the structure of cropping systems in semi-arid tropics of India in 16 villages of Andhra Pradesh, Maharashtra, Karnataka and Gujarat for the year 2010. Area under cotton based cropping systems, paddy and wheat and horticultural crops based cropping systems is higher even in dry lands. The net returns are more in cotton, paddy and wheat, horticultural based cropping systems mostly driven by technological improvements and subsidized inputs and improved seeds. Whereas pulses based cropping systems are benefited from higher market prices. In addition to the higher net returns pulse based cropping systems enhances the soil nutrients, hence needs to be encouraged through subsidized seed supply (Venkateswarlu, et al.,2007). The study clearly shows that these input and labour intensive cropping systems like cotton, paddy and wheat based cropping systems are also more profitable across many of the SAT villages compared to traditional coarse cereal based cropping systems. The horticultural based cropping systems are picking up due to their less labour intensive nature and higher profitability. All the villages in SAT are experiencing the shortage of labour as indicated by higher marginal returns compared the prevailing wage rates. The labour use per hectare decreased and farm mechanization increased with the farm size. The feminization is having inverted "U" shape relationship with farm size. This indicates that the farms with more than five hectares of land are detrimental to women employment as farm mechanization in large farms replaces women labour. The use of seed and other expenses (which include irrigation, pesticides, FYM, etc.,) are less than optimum levels, which needs to be rectified, given the possible higher returns to high-input-high-output cropping systems based on cotton, paddy, wheat and other commercial crops like fruits and vegetables crops etc. The high level of significance of village dummies in the regression equation indicates that the returns to agricultural sector vary significantly among villages in the SAT states. This indicates that the future policies to address incomes of the farmers require location specific strategies.

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References

Arun S. 2012. 'We are farmers too': agrarian change and gendered livelihoods in Kerala, South India. Journal of Gender Studies, 21(3): 271-284.

Birthal PS, Joshi PK, Roy D, Thorat A. (2013). Diversification in Indian Agriculture toward High-Value Crops: The Role of Small Farmers. Canadian Journal of Agricultural Economics, 61(1), 61-91.

Mundlak Y, Butzer R, Larson DF. 2012. Heterogeneous technology and panel data: The case of the agricultural production function. Journal of Development Economics, 99(1), 139-149.

Ramasundaram P, Suresh A, Chand A. 2011. Manipulating Technology for Surplus Extraction: The Case of Bt Cotton in India, Economic & Political Weekly, Vol. xlvi (43): 23-26

Reddy AA. 2009. Pulses Production Technology: Status and Way Forward, Economic and Political Weekly, 44(52): 73-80.

Reddy AA. 2011. Sources of Agricultural Growth in Andhra Pradesh, India, Scope for Small Farmer Participation, The Indian Economic Journal • Volume 59(3):88-108.

Tripp R and Pal S. 2001. The private delivery of public crop varieties: Rice in Andhra Pradesh. World Development, 29(1): 103-117.

Venkateswarlu B, Srinivasarao CH, Ramesh G, Venkateswarlu S, Katyal JC. 2007. Effects of long-term legume cover crop incorporation on soil organic carbon, microbial biomass, nutrient build-up and grain yields of sorghum/sunflower under rain-fed conditions. Soil use and management, 23(1), 100-107.

Vepa SS. 2005. Feminisation of agriculture and marginalisation of their economic stake, Economic and Political Weekly, 40 (25): 2563-68.