

Water Resources and Farming Systems under Krishna River Sub-basin between Nagarjuna Sagar and Prakasham Barrage, Andhra Pradesh, India

R. Vijaya Kumari^{1*}, M. Devender Reddy¹ and Prem Binderban²

¹Water Technology Center, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad, India

²Alterra, International Livestock Research Institute, Wageningen University, Netherlands

Article History

Manuscript No. 250

Received in 3rd January, 2012

Received in revised form 23rd August, 2012

Accepted in final form 5th September, 2012

Correspondence to

*E-mail: ramalingareddyvijaya@gmail.com

Keywords

Krishna river, farming systems, agriculture, income, returns, irrigation

Abstract

A study was undertaken in Krishna river sub-basin (between Nagarjuna Sagar and Prakasham barrage) with an objective to assess the current farming systems and opportunities to introduce alternative farming systems. The sub-basin covers 192 mandals in 17 revenue divisions of seven districts, i.e. Mahaboobnagar, Khammam, Nalgonda, Warangal, Rangareddy, Krishna and Guntur. Survey was conducted in 27 mandals across 16 revenue divisions covering 135 farmers. The size of the land holding differed with source of irrigation. The size of the land holding was greater under rain-fed situation followed by canals and tube wells. The predominant cropping situations observed are paddy-paddy sequence under canal irrigation in black soils (22.2%). It was followed by cotton under rain-fed situation (21.5%) and paddy-paddy sequence (12.6%) under tube well. According to source of irrigation, cotton was predominant under rain-fed conditions (36.3%) followed by paddy-paddy sequence under canal irrigation and tube wells (25.9%). Higher gross and net returns were obtained by growing chili under different irrigation sources followed by sugarcane, cabbage and cotton. The farming system returns were higher wherever they were under canal + tube well or open wells. The returns were higher with agriculture + dairy + goat/sheep with open wells + tube wells + canal followed by agriculture and dairy with tube well, canal and rain-fed. The average annual income of large farmers was higher in Guntur district (₹ 2,77,748) followed by Khammam and Krishna districts. It was mainly contributed by agricultural crops and sheep and goat rearing. It can be concluded that the adoption of agriculture with dairy and sheep or goat rearing under irrigation will be more remunerative than agriculture alone.

1. Introduction

The Krishna River has its origin near the west coast of India and its delta is located in the State of Andhra Pradesh at the east coast. The watershed comprises an area of 250,000 km², being equivalent to approximately 8% of the surface area of India as a whole. In Andhra Pradesh, rice is a major crop that uses excessive amounts of water kg⁻¹ of rice produced. The reliance on rainfall is high, but the low and erratic nature of the monsoons in this tropical semi-arid zones leads to moisture deficit for crop production. The farmers receive irrigation water, but they have little control over its availability. The performance of large irrigation systems may be evaluated using several criteria, including agricultural productivity, reliability of water supply, and equity of water distribution over the command area (Bhutta and Van der Velde 1992; Bos 1997; Gorantiwar and Smout 2005). Gaur et al. (2008) adopted an integrated

approach to assess how cropping patterns and the spatial equity of canal flow changed with water supply shocks in the left canal command area of Nagarjuna Sagar. The cropping pattern in a region depends on environment, soil type, rainfall, irrigation facilities, nearness to markets and profitability. Besides these, the socioeconomic conditions of farmers in the region will also decide the farming system. Among these, the rainfall and irrigation plays major role that influence the crops, cropping system, and farming systems. Generally, crops and cropping systems can be selected to reduce water requirement. Keeping these facts in view, a study was undertaken by ANGRAU in association with ALTERRA, ILRI, Wageningen University, Netherlands in Krishna sub-basin between Nagarjuna Sagar and Prakasham barrage with an objective of assessing the current farming systems and opportunities to introduce alternative farming systems.



2. Materials and Methods

The sub-catchments that discharge into the Krishna River between the Nagarjuna Sagar Project and the Prakasham Barrage of Vijayawada (36,000 km²) were selected as study area. Given the objectives of the project, the most relevant farming systems in the study area through a survey and assess the freedom of choice for farmers in setting up their farming systems considering both market and non-market factors and also internal and external factors that influence farm activities under scope for improvement of agricultural benefits by allocative water management have been studied. A questionnaire was developed to collect farm data that allow analyses for addressing pre-determined objectives. The entire sub-catchment covers 192 mandals in 17 revenue divisions of seven districts, i.e. Mahaboobnagar, Khammam, Nalgonda, Warangal, Rangareddy, Krishna and Guntur. Among these districts the highest number of mandals were observed in Nalgonda district (59 Mandals), followed by Warangal (32 Mandals), Ranga Reddy (28 Mandals), Guntur (26 Mandals), Khammam (26 Mandals), Krishna (16 Mandals), Mahaboobnagar (5 Mandals). Survey was conducted in 27 mandals under 16 revenue divisions and a total of 135 farmers were surveyed during May 2006-Mar 2007 (Table 1).

3. Results and Discussion

3.1. Rainfall

Normal rainfall in the districts under Krishna river basin ranged from 604.7 mm (Mahaboobnagar) to 1124.0 mm (Khammam), the highest amount of rainfall being recorded in Khammam district (Table 2).

3.2. Land holdings

The data in Table 3 and 4 shows that the marginal farmers were identified only in Ranga Reddy district with an average land holding of 0.4 ha. The small farmers were identified in all the districts except Khammam with an average land holding of 1.8 ha. The large farmers were observed in all the districts surveyed where the size of land holding ranged from 3.2 to 4.5 ha. Nalgonda district have more number of large farmers (26) followed by Warangal (20) and Guntur (19) districts. The average land holding of sample farmers in this basin ranges from 2.7 to 4.8 ha. Among the sampled farmers, 82.2% were large farmers, 23% were small farmers and only 1% was marginal farmers. Except in Ranga Reddy district, in all other surveyed districts, large farmers were 80-100%. There were no small farmers in Khammam district and small farmers constitute only 5% in Guntur and 36% in Rangareddy district, while in other districts it ranged from 13 to 20%.

3.3. Source of income

In this region agriculture was found to be the main source of income (Table 5). Among 135 farmers interviewed, the main

occupation of 71 farmers (52.6%) was agriculture followed by a combination of agriculture and business. A very less number of farmers found to be dependent on livestock management (5%). Only a few farmers of Krishna, Nalgonda, Rangareddy and Warangal are dependent on livestock-based farming system.

3.4. Irrigation source and number of farmers

The main source of irrigation in this basin was tube wells and canals. Drip irrigation was followed only in Rangareddy district. The large farmers of Nalgonda and Warangal districts mainly depend on rain-fed agriculture and tube wells.

3.5. Irrigation source and size of land holding

Size of the land holding differed with source of irrigation. Irrespective of the district, the size of the land holding is the maximum under rain-fed situation followed by canals and tube wells. Under open wells the maximum size of land holding (2.8 ha) was observed in Guntur district, under tube wells the maximum size of land holding (2.1 ha) was observed in Rangareddy and under rain-fed situation the size of land holding was maximum in Mahaboobnagar district (5.2 ha). The average size of holding under ground water is 0.4 ha, but for small farmers it was 1.3 ha and for large farmer 1.5 ha. Under surface water, the average land holding for marginal, small and large farmers was 0.4 ha, 1.4 ha and 2.5 ha, respectively.

3.6. Irrigation source, soil types and crops grown

In this basin the soil types observed are black, red, sandy black, red sandy and sandy loam soils. The predominant cropping situations observed are paddy-paddy sequence under canal irrigation in black soils (22.2%) followed by cotton under rain-fed situation (21.5%) and paddy-paddy sequence (12.6%) under tube well. Under rain-fed situation, cotton, red gram, and castor were grown in Kharif season. Cropping situations were less under tank irrigation/bore wells/rain-fed condition in red or sandy soils. National Rain-fed Area Authority (NRAA, 2011) found black, red, lateritic, mixed, saline and alkaline soils as important soil types in the Krishna river basin with persisting diversified cropping pattern (paddy, sorghum, corn, sugarcane, millet, cotton, sunflower, groundnut, turmeric, banana and a variety of horticultural crops). Sharma et al. (2008) observed groundnut in the kharif followed by maize in the rabi, seems to be a good combination for less water use and high net returns in Polavaram-Vijayawada link project. Similarly, the project area has a large area under annual crops and plantations, but yield levels of these enterprises are sub-optimal and need to be significantly improved to realize higher values unit⁻¹ of water utilized.

3.7. Irrigation source-wise crops grown in different seasons

According to source of irrigation cotton was predominant under rain-fed conditions (36.3%) followed by paddy-paddy sequence under canal irrigation and tube wells (25.9%). Maize

Table 1: Selected Mandals in Krishna River sub-basin for primary data collection

District	Revenue division	Sl. No.	Mandal	No. of farmers interviewed
Guntur	Narsaraopet	1	Pedakurapadu	5
		2	Rompicherla	5
		3	Gurazala	5
		4	Durgi	5
Khammam	Khammam	5	Khammam urban	5
		6	Madhira	5
		7	Wyra	5
Mahaboobnagar	Jadcherla	8	Shadnagar	5
Nalgonda	Miryalaguda	9	Vemulapally	5
		10	Huzur Nagar	5
		11	Athmakur	5
	Bhuvangiri	12	Nothanakal	5
		13	B. Ramaram	5
		14	Mothkur	5
Krishna	Vijayawada	15	Chandarlpadu	5
		16	Veerullapadu	5
		17	Gampalagudam	5
Rangareddy	Nuziveed	18	Pargi	5
		19	Shabad	5
	Chevella	20	Kandukur	5
		21	Ibrahimpattanam	5
	Vikarabad	22	Tandur	5
Warangal	Mulugu	23	Mulugu	5
	Warangal	24	Hasanparthy	5
	Jangaon	25	Raghunathpally	5
	Mahabubabad	26	Maripeda	5
	Narsampet	27	Kanapur	5
Total				135

Table 2: Normal rainfall in the districts selected under Krishna river sub-basin

District	Normal rainfall (mm)
Guntur	851.0
Khammam	1124.0
Mahaboobnagar	604.7
Nalgonda	1091.0
Warangal	1048.1
Ranga Reddy	781.5

based cropping system; *jowar*/vegetable-based cropping system was less under all irrigation sources. The predominant crops grown under rain-fed conditions were cotton, red gram, castor, *subabul* and chilies, whereas under canal irrigation the crops

grown were paddy, cotton and maize, while the same under tube wells are paddy, cotton and vegetables.

3.8. Soil type and cropping systems in different seasons

Based on soil type, in the black soils, the paddy-paddy sequence was predominant (45.9%) followed by cotton (31.9%). But in red soils the mostly preferred crop is red gram (10.4%). In sandy soils the mostly cultivated crops were vegetables, chilies and castor. The lowest numbers of cropping situations were observed in black soils with maize and green gram cultivation.

3.9. Returns

The highest gross and net returns were obtained by growing chili under different irrigation sources followed by sugarcane, cabbage and cotton (Table 6). The lowest returns were obtained by growing green gram and *jowar*.

Table 3: District-wise number of farmers with different size of land holdings in study area

District	Marginal farmers	Small farmers	Large farmers	Total
Guntur		1 (5)*	19 (95)*	20 (14.8)**
Khammam			15 (100)	15 (11.1)
Krishna		3 (20)	12 (80)	15 (11.1)
Mahaboobnagar		1 (20)	4 (80)	5 (3.7)
Nalgonda		4 (13.9)	26 (87)	30 (22.2)
Rangareddy	1 (4)	9 (36)	15 (60)	25 (18.5)
Warangal		5 (20)	20 (80)	25 (18.5)
Total	1 (0.7)	23 (17.0)	111 (82.2)	135 (100)

*Figures in parenthesis are percentage to total number of sample farmers in each of their respective district; **Figures in parenthesis are percentage to total number of sample farmers in all the districts

The highest B:C ratio was obtained with paddy-paddy sequence under open well in black soils. It was followed by paddy-paddy sequence in sandy loam soils under open well situation and cotton + red gram cropping under canal irrigation in black soils. The average annual income of large farmers was higher (₹ 2,77,748) in Guntur district (Table 7).

This was mainly contributed by agricultural crops and sheep and goat rearing. It was followed by Khammam and Krishna districts. The lowest income was obtained in Mahaboobnagar district. However, the small farmers of Krishna and Nalgonda districts were realizing more income than the other districts.

3.10. Farming systems

In small farms, agriculture + dairy + poultry farming system found to be produced higher annual returns followed by

Table 4: District-wise average land holding size (ha) of sample farmers in the study area

District	Marginal farmers	Small farmers	Large farmers	Pooled
Guntur		2	4.5	4.3
Khammam			4.0	4.0
Krishna		1.7	3.3	2.9
Mahaboobnagar		2	5.6	4.8
Nalgonda		1.9	3.5	3.2
Rangareddy	0.4	1.7	3.3	2.7
Warangal		2.0	3.2	2.9
Pooled	0.4	1.8	3.7	3.4

agriculture + dairy and agricultural + goat farming system (Table 8).

Further, under different sources of irrigation, agriculture and agriculture + dairy under canal irrigation were found to give higher returns than of tube wells and rain-fed. The returns were lower in case of open wells + tube wells + tank. Agriculture + dairy and poultry under open wells and canal condition was higher than that under open well, tube well and tank. Under large farms, agriculture under tube wells recorded higher returns and this was followed by agriculture under tube well + canal + rain-fed. The agriculture + dairy has given higher returns over that of agriculture + dairy + goat/sheep or agricultural + goat/sheep + poultry. This may be due to less productivity and returns resulted from these enterprises due to inefficient management of too many number of enterprises on the farm by the large farmers.

Agriculture and sheep/goat under canal + rain fed condition, agriculture + dairy + poultry under open well and canal was found to give higher returns. The farming system returns were high wherever they were under canal + tube well or open wells. The highest returns were found to be higher with agriculture + dairy + goat/sheep with open wells + tube wells + canal followed by agriculture and dairy under tube well, canal and rain fed situation.

The results on income unit⁻¹ area generated from different farming systems in each district of the study area under small and large farms is presented in Table 9. The data revealed that under small farms, the performance of agriculture alone and agriculture + dairy are the most remunerative systems in Khammam. This was followed by Rangareddy and Krishna in case of agriculture and Nalgonda and Rangareddy in case of agriculture + dairy.

Whereas on large farms, the combination of agriculture with dairy and sheep/goat outperformed than any other farming systems in the study area. With regard to agriculture alone, Rangareddy ranked first with the highest income of ₹ 80096 followed by Guntur and Krishna with income of ₹ 62,394 and 38,774, respectively. However, in case of agriculture + dairy, Guntur topped the list with the highest income of ₹ 68,327 followed by Khammam and Krishna with income of ₹ 60,811 and ₹ 55,857, respectively. Moreover, agriculture + dairy and agriculture + sheep/goat farming system were also found to be better in producing income in many districts of the study area.

3.11. Farmer's opinion on existing farming system

Farmers are not ready to change the existing farming system because of availability of resources (71%) and also the irrigation facilities up to some extent (Table 10). Majority of the farmers (55%) in the study area opined that lack of labor is a major constraint in farming. Further, the farmers are adopting a particular

Table 5: Income sources of sample farmers in the study area (2007)

District	Agriculture as main occupation	Business as main occupation	Agriculture and business	Agriculture and dairy	Agriculture and goat raring	Total
Guntur	12 (60)*		7 (35)*		1 (5)*	20 (14.8)**
Khammam	11 (73.3)		4 (27)			15 (11.1)
Krishna	2 (13.3)		9 (60)	2 (13.3)*	2 (13.3)	15 (11.1)
Mahaboobnagar	2 (40)		2 (40)		1 (20)	5 (3.7)
Nalgonda	16 (53.3)		12 (40)	1 (3.3)	1 (3.3)	30 (22.2)
Rangareddy	11 (44)	3 (12)*	8 (32)	1 (4)	2 (8)	25 (18.5)
Warangal	17 (68)		5 (20)	3 (12)		25 (18.5)
Total	71 (52.6)	3 (2.2)	47 (34.8)	7 (5.2)	7 (5.2)	135

*Figures in parenthesis are percentage to total number of sample farmers in each of their respective district; **Figures in parenthesis are percentage to total number of sample farmers in all the districts

Table 6: Economics of different cropping systems in the study area

Sl. No.	Soil type	SI	A	C P		B	Y	G	N	B:C	C	Y	G	N	B:C
				<i>Kharif</i>	<i>Rabi</i>			<i>Kharif</i>					<i>Rabi</i>		
1	Black	Canal	31	Paddy	Paddy	22601	51	37823	15227	0.67	20338	54	39575	19238	0.95
2	Black	T	16	Paddy	Paddy	20906	52	38198	17292	0.83	18180	53	38434	20255	1.11
3	Red	R	14	R G		9071	11	20625	11554	1.27					
4	Red	R	12	Castor		9563	14	21333	11771	1.23					
5	Black	Tank	13	Paddy	Paddy	18608	49	35492	16885	0.91	17740	52	37437	19696	1.11
6	S L	Canal	3	Paddy	Paddy	23000	60	42500	19500	0.85	20583	58	38292	17708	0.86
7	Black	O W	3	Paddy	Paddy	16167	52	33792	17625	1.09	16167	55	40175	24008	1.49
8	Red	O W	1	Paddy	Paddy	17875	53	33750	15875	0.89	19875	55	40650	20775	1.05
9	S L	O W	4	Paddy	Paddy	17880	54	35419	17539	0.98	19050	60	41600	22550	1.32
10	Red	T	2	Paddy	Paddy	22250	50	34375	12125	0.54	19125	55	38000	18875	0.99
11	S L	T	7	Paddy	Paddy	21964	51	36393	14429	0.66	18143	52	37432	19289	1.06
12	S B	T	3	Paddy	Paddy	22758	53	39233	16475	0.72	19750	49	33083	13333	0.68
13	Black	B W	2	C		32000	34	74250	42250	1.32					
14	Black	Canal	4	C		26813	30	45750	45542	1.70					
15	Black	R	20	C		28244	29	63838	35469	1.26					
16	Red	R	2	C		29563	31	57500	27938	0.95					
17	S L	R	10	C		31363	28	58350	26988	0.86					
18	Black	Tank	7	C		26000	26	52857	26857	1.03					
19	Black	T	8	C		29063	27	62031	32969	1.13					
20	S C	T	3	C		30917	30	72500	42417	1.37					
21	Black	T	4	C		26250	28	63250	37000	1.41					

SI = Source of irrigation; A = No. of sample farmers; C P = Cropping pattern; B = Cost of cultivation (₹ ha⁻¹); Y = Yield (q ha⁻¹); G = Gross returns (₹ ha⁻¹); N = Net returns (₹ ha⁻¹); B:C = B:C ratio; T = Tube well; R = Rain fed; R G = Red gram; O W = Open well; B W = Bore well; S L = Sandy loam; S B = Sandy black; S C = Sandy clay; R S = Red sandy; C = Cotton; M = maize; R = red gram

Table 6: Economics of different cropping systems in the study area (Continue)

22	Black	Canal	2	C + M	26125	30	75000	48875	1.87	17875	50	15250	10875	0.61
23	Black	Canal	4	C + R	27188	23	48313	21125	0.78	9563	12	21375	11813	1.24
24	Black	R	12	Chili	45094	48	169479	124490	2.76					
25	Black	T	2	Chili	40313	44	175000	134688	3.34					
26	Black	Tank	1	Chili	48500	50	200000	151500	3.12					
27	R S	R	4	Chillies	39563	41	150000	110438	2.79					
28	S B	R	5	Chillies	32350	44	138000	105650	3.27					
29	S B	T	5	Chillies	42800	44	152750	109950	2.57					
30	S B	R	1	Chillies	32750	38	112500	79750	2.44					
31	R S	R	3	Subabul	23333	50	65000	41667	1.79					
32	S B	R	4	Subabul	18750	63	82656	63906	3.41					
33	Black	R	4	Subabul	20000	56	73594	53594	2.68					
34	S L	R	4	Castor	12438	15	21688	9250	0.74					
35	R S	R	1	Castor	12375	13	21250	8875	0.72					
36	S L	R	6	Castor	12427	15	21615	9188	0.74					
37	Black	R	3	R	9542	11	20833	11292	1.18					
38	R S	R	5	R	9850	14	24900	15050	1.53					
39	Red	Tank	5	R	10125	11	20100	9975	0.99					
40	S B	R	3	R + M	8750	11	21250	12500	1.43	17333	46	27500	10167	
41	Red	R	4	R + M	8313	12	19875	11563	1.56	13313	43	23688	10375	
42	Black	Canal	3	M	16917	46	17667	9750	1.69					
43	S B	R	5	M	16167	46	27500	11333	1.83					
44	Red	T	4	M	13250	50	26094	12844	1.96					
45	S L	T	4	M	14000	49	27219	13219	2.09					
46	Red	R	5	M	15150	49	26275	11125	2.22					
47	S L	T	4	M	16438	54	30500	14063	2.36					

Table 7: Average annual income (source-wise) of farmers in Krishna river basin districts (₹ unit⁻¹ farm)

Dist.	Source-wise average income														
	Marginal farmers			Small farmers					Large farmers						
	A	B	T	A	B	C	D	E	T	A	B	C	D	E	T
G				2	74,250				74,250	4.5	2,58,801	15,263	70,000		2,77,748
K M										4	1,47,835	19,400	70,000		1,71,901
K				1.7	79,267	23,333			1,02,600	3.3	1,33,492	10,000	60,000		1,53,492
M				2	36,200		30000		66,200	5.6	56,288	12,500	37,500	500	1,06,413
N				1.9	68,663	32,500			1,01,163	3.5	99,695	20,862	2,154	300	1,22,722
R	0.4	71,800	71,800	1.7						3.3	1,03,207	14,667			1,17,873
W				2	63,446	18,000		1000	81,646	3.2	1,11,199	16,750	1,579	517	1,29,604

A = Average farm size (ha); B = Agricultural crops; C = Dairy; D = Sheep & goat; E = Poultry; T = Total; G = Guntur; K M = Khammam; K = Krishna; M = Mahaboobnagar; N = Nalgonda; R = Rangareddy; W = Warangal; No C, D and E for marginal farmers

Table 8: Farming systems followed under sources of irrigation and income generated by different farm sizes in Krishna basin

Farming system	Irrigation source	No. of sample farmers	Amount (₹ unit ⁻¹ farm)	Amount (₹ ha ⁻¹)
M-Agriculture (0.4 ha)	Tube well + rain-fed	1	71800	179500
S-Agriculture (2 ha)	Tank + rain-fed	1	68000	34000
S-Agriculture (2 ha)	Canal	1	215050	107525
S-Agriculture (2 ha)	Rain-fed	1	85000	42500
S-Agriculture (1.9 ha)	Tube well	4	84230	44332
S-Agriculture (1.9 ha)		7	100710	53005
S-Agriculture (2 ha) + dairy (1)	Open well + tube well + tank	1	72380	36190
S-Agriculture (2 ha) + dairy (1)	Open well + canal	1	82700	41350
S-Agriculture (2 ha) + dairy (4)	Tank + rain-fed	1	85200	42600
S-Agriculture (2 ha) + dairy (1)	Tube well + rain-fed	1	95700	47850
S-Agriculture (1.9 ha) + dairy (3.5)	Canal	4	112238	59073
S-Agriculture (1.6 ha) + dairy (2)	Tube well	1	78600	49125
S-Agriculture (1.9 ha) + dairy (2.6)		9	95948	50499
S-Agriculture (2 ha) + dairy (2) + poultry (3)	Open well + tube well + tank	1	92180	46090
S-Agriculture (1.8 ha) + dairy (2.5) + poultry (8.5)	Open well + canal	2	161100	89500
S-Agriculture (1.9 ha) + dairy (2.3) + poultry (6.7)		3	138127	72698
S-Agriculture (1.2 ha) + goat/sheep (25)	Tank	1	93000	77500
S-Agriculture (2 ha) + goat/sheep (15)	Tube well + rain-fed	1	66200	33100
S-Agriculture (1.6 ha) + goat/sheep (20)		2	79600	49750
L-Agriculture (6.4 ha)	Open well + tube well + rain-fed	2	82725	12926
L-Agriculture (3.6 ha)	Open well + tube well + tank	1	84720	23533
L-Agriculture (3.4 ha)	Open well + tube well	2	174175	51228
L-Agriculture (3.2 ha)	Tube well + tank + rain-fed	1	90600	28313
L-Agriculture (7.4 ha)	Tube well + canal + rain-fed	2	596700	80635
L-Agriculture (3.4 ha)	Tube well + canal	5	168210	49474
L-Agriculture (4.5 ha)	Tube well + rain-fed	13	132735	29497
L-Agriculture (3.5 ha)	Tube well	5	379920	108549
L-Agriculture (4.1 ha)	Tank	3	118609	28929
L-Agriculture (3.1 ha)	Canal + rain-fed	3	101317	32683
L-Agriculture (5.5 ha)	Canal	5	194650	35391
L-Agriculture (4.4 ha)		42	190042	43191
L-Agriculture (4.1 ha) + dairy (3.3)	Open well + tube well + rain-fed	3	196833	48008
L-Agriculture (2.8 ha) + dairy (3)	Open well + tube well + tank	1	205420	73364
L-Agriculture (2.4 ha) + dairy (2)	Open well + tube well + canal	1	184500	76875
L-Agriculture (2.8 ha) + dairy (3.5)	Open well + tube well	2	190333	67976
L-Agriculture (4 ha) + dairy (4.5)	Open well + rain-fed	2	201675	50419
L-Agriculture (4.4 ha) + dairy (8)	Open well + canal	1	222150	50489
L-Agriculture (3.6 ha) + dairy (2)	Tube well + canal + rain-fed	3	346413	96226

M = Marginal; S = Small; L = Large

Table 8: Farming systems followed under sources of irrigation and income generated by different farm sizes in Krishna basin (Continue)

L-Agriculture (4.9 ha) + dairy (2.7)	Tube well + tank + canal	1	136700	27898
L-Agriculture (3.9 ha) + dairy (3.6)	Tube well + canal	7	248979	63841
L-Agriculture (2.4 ha) + dairy (4)	Tube well + tank + rain-fed	2	91450	38104
L-Agriculture (3.3 ha) + dairy (3.3)	Tube well + rain-fed	15	162013	49095
L-Agriculture (3.6 ha) + dairy (3)	Tube well + tank	1	187100	51972
L-Agriculture (2.8 ha) + dairy (3)	Tank + rain-fed	3	147817	52792
L-Agriculture (3.6 ha) + dairy (5.5)	Tank	2	183710	51031
L-Agriculture (4.2 ha) + dairy (5.5)	Canal + rain-fed	2	238800	56857
L-Agriculture (4 ha) + dairy (3.3)	Canal	10	209507	52377
L-Agriculture (3.6 ha) + dairy (3.5)		56	198020	55006
L-Agriculture (3.2 ha) + dairy (5) + goat/sheep (25)	Open well + tank	1	129330	40416
L-Agriculture (2.4 ha) + dairy (2) + goat/sheep (29)	Open well + tube well + canal	1	245640	102350
L-Agriculture (4.8 ha) + dairy (3) + goat/sheep (15)	Tube well + tank	1	140640	29300
L-Agriculture (3.5 ha) + dairy (3.3) + goat/sheep (23)		3	171870	49106
L-Agriculture (4 ha) + goat/sheep (30)	Tube well + tank	1	127890	31973
L-Agriculture (6.4 ha) + goat/sheep (20)	Canal + rain-fed	1	363300	56766
L-Agriculture (2.6 ha) + goat/sheep (27.5)	Tube well + rain-fed	2	108350	41673
L-Agriculture (2.4 ha) + goat/sheep (35)	Rain-fed	2	140700	58625
Agriculture (3.4 ha) + goat/sheep (29.2)		6	164932	48509
L-Agriculture (3.4 ha) + dairy (8) + poultry (5)	Open well + canal	1	174300	51265
L-Agriculture (4.3 ha) + dairy (2) + poultry (4.3)	Open well + tube well + tank	3	197403	45908
L-Agriculture (2.8 ha) + dairy (5) + poultry (4)	Open well + tank	1	136150	48625
L-Agriculture (3.8 ha) + dairy (3.8) + poultry (4.4)		5	180532	47508
L-Agriculture (3.2 ha) + dairy (2) + goat/sheep (90) + poultry (5)	Rain-fed	1	165500	51719

Table 9: District wise income (₹ ha⁻¹) unit¹ area generated under different farming systems in the study area

Farming System	Small						
	G	K	KR	M	N	R	W
Agriculture	37125	107525	42500	33100		43509	32711
Agriculture + dairy		83450			49483	45526	38770
Agriculture + sheep/goat						77500	
Agriculture + dairy + sheep/goat							
Agriculture + dairy + poultry							72698
Agriculture + dairy + sheep/goat + poultry							
	Large						
	G	K	KR	M	N	R	W
Agriculture	62394	22639	38774	14387	19974	80096	
Agriculture + dairy	68327	60811	55857		46801	54008	45262
Agriculture + sheep/goat	56813		58625	42964	31973		40167
Agriculture + dairy + sheep/goat		102350			40416		
Agriculture + dairy + poultry					28498		56271
Agriculture + dairy + sheep/goat + poultry				51719			

G = Guntur; K = Khammam; KR = Krishna; M = Mahaboobnagar; N = Nalgonda; R = Rangareddy; W = Warangal

Table 10: Opinion of sample farmers of study area on existing farming system

		Number of farmers opinion	Percentage
Satisfying existing farming system	Yes	41	30.3
	Some extent	46	34.3
	No	49	36.3
He is willing to shift any other crops	Yes	31	23.0
	Some extent	42	31.1
	No	62	45.9
Specific reason for adopting existing farming system	Market demand	15	11.1
	Climatic conditions	7	51.9
	Local adaptability	14	10.4
	Resources available	71	52.6
	Irrigation facilities	23	17.0
	Traditional	5	37.1
What is the aim behind adopting the particular existing farming system	Maximizes profit	71	52.6
	Daily income	5	3.7
	Minimize risk	20	14.8
	Profit and resource conservation	21	15.6
	Satisfaction of family needs	5	3.7
	Seasonal income	13	9.6
	Irrigation facilities	16	11.9
	Labor	55	40.7
Major biotic/abiotic constraints	Marketing	19	14.1
	Power	9	6.7
	Rainfall	19	14.9
	Weather hazards	17	12.6

farming system for maximizing profit under existing sources.

4. Conclusion

From this study, it can be concluded that the size of the land holding was greater under rain-fed situation followed by canals and tube wells. The predominant cropping situations observed are paddy-paddy sequence under canal irrigation in black soils (22.2%) followed by cotton under rain-fed situation (21.5%) and paddy - paddy sequence (12.6%) under tube well. According to source of irrigation cotton was predominant under rain-fed conditions (36.3%) followed by paddy-paddy sequence under canal irrigation and tube wells (25.9%). Higher gross and net returns were obtained by growing chili under different irrigation sources followed by sugarcane, cabbage and cotton. The farming system returns were higher under canal + tube well or open wells.

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