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Land Allocation Decisions in a Tank Command in Karnataka: A Study of Risk Profiles

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ABSTRACT. This study focuses on risk management strategies for a tank irrigated command, through the evolution of optimal crop models for areas located at different distances from the tank. The specific objective of the study is to develop an optimum crop pattern under conditions of risk for which the minimization of the total absolute deviation (MOTAD) technique was used. The existing cropping pattern of the farmers in the command area is characteristic of an over riding concern for sustainability with risk consideration importance. For high risk profiles the model recommended specialisation as against diversification for low risk. Farmers growing diverse crops on their fields tended to include leguminous and deep rooted crops which was not entirely dictated by profitability considerations, but due to an abiding concern for preserving the soil fertility.

INTRODUCTION

Irrigation has become *sine qua non* of agriculture and rural development in India. Without adequate and timely water supplies, the potential of high-yielding varieties, fertilizers, pesticides and other improved cultivation techniques cannot be realised. The major sources of irrigation are tanks, canals and wells. Tanks constitute the oldest means of providing irrigation water. However tank irrigated area has been dwindling over the years. Furthermore, the tanks have attained the status of an unreliable source of irrigation and the farmers are exposed to high degrees of risks and uncertainty. Water being a scarce resource, its judicious utilisation to obtain maximum returns is imperative. Several studies have been undertaken on tank management, its constraints and performances (Palanisami and Easter, 1984).

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However, little work has been done on studying the impact of risk on the cropping patterns in tank command areas.

This study focuses on the risk aspects of tank irrigation with the objective of developing optimal crop patterns for different reaches of the tank command consistent with varying levels of risk.

The study was carried out at the macro level for the entire tank command area to develop an optimum land use pattern for various levels of risk at different reaches of the tank command.

MATERIALS AND METHODS

Gundamgere tank situated in Doddaballapur Taluk in Karntaka, an important tank in the region, was selected for the study. This tank has a command area spanning 407 hectares and a catchment area of 41 sq.km.

The tank command was divided into three regions based on the distance from the tank. This was done as location of the land had a bearing on the water availability and consequently on the cropping pattern. The identified regions were the upper, middle and lower reaches situated up to 1050, 2100 and 3150 meters respectively, from the tank. A sample of 90 farmers were drawn, distributed equally between the 3 regions.

Data pertaining to the crops grown, inputs used and the output and values realised were collected from the respondents for the year 1994–95. In addition yields of the various crops in the tank command were collected for the previous 5 years as well, to facilitate the study of risk.

Linear programming with parametric provisions is a valuable tool in water resource planning. The optimal crop patterns were generated using MOTAD (Minimisation of Total Absolute Deviations) model developed by Hazell (1971). Input-output coefficients were derived from the sample and command level aggregate areas as constraints. The model was used by Mruthyunjaya and Sirohi (1979) in developing plans for drought prone areas.

The model can be stated as follows:

$$Minimise\ Z = \sum_{h=1}^{S} Y^{-}_{h} + Y^{+}_{h}$$

Subject to

$$\sum_{j=1}^{n} (C_{hj} - g_j) X_j + Y^-_h \leq 0 \quad (for\ h,\ h = 1, 2 \ldots\ldots\ldots s)$$

$$\sum_{j=1}^{n} f_j X_j \quad (0 - unbounded)$$

$$\sum_{j=1}^{n} a_{ij} X_i \leq bi \quad (for,\ ij = 1, 2 \ldots\ldots\ldots m)$$

and,

$$X_j,\ Y^-_h \geq 0 \quad (for\ j, h)$$

where;

Z	=	Sum of the absolute values of the negative and positive deviations of the gross incomes of crop activities, from their respective mean values.
Y^-_h and Y^+_h	=	Absolute values of the negative and positive value of the total gross income deviations in respect of activities in the h^{th} year from their mean.
X_j	=	With the levels of 'j' decision variable which pertains to area of crop 'j'.
C_{hj}	=	Gross returns of j^{th} activity in the h^{th} year.
g_j	=	Mean values of the gross return of the j^{th} activity.
f_j	=	Gross margin coefficient of j^{th} activity in Rs/acre.
a_{ij}	=	Input coefficient of the i^{th} resource of the j^{th} activity.
bi	=	Availability of i^{th} resource.
S	=	Number of time series observation, and
n	=	Number of activities.

The variation in total gross margins were examined by computing the standard deviation and coefficient of variation (Reddy, 1997).

The analysis was carried out imposing a credit limit of Rs. 5000/ household which was about the average level of borrowing among the sample households. Further, two levels of risk were studied to discern their impact on the cropping pattern which was juxtaposed with the existing cropping pattern of the sample.

Low risk

This was formulated to accommodate a level of risk, where 70% of expected income from the existing resources was targeted.

High risk

This derives the optimum land use pattern with a higher level of risk, where the target income was set at 90% of the expected income.

RESULTS AND DISCUSSION

Upper reach

The results of land utilization with low risk among farmers of the upper reach are presented in Table 1. It is observed that during the Kharif season the model recommended a decrease in area under ragi to 21.08 acres primarily to meet the food requirement of the households as well as for fodder purpose, which it was constrained to satisfy at the outset. There was no change in area under maize in red soils, but in black soils area under maize increased marginally. During the Rabi season, same significant changes are indicated. Sunflower is recommended on 21 acres in sandy soil and 6.75 acres of red soils. Black soils were to be left fallow. However, with an increase in the level of risk, much of the fallow land is to be brought under sunflower cultivation in red soils during the Rabi season. The major casualty in this shift is groundnut.

In the Kharif dryland areas situated outside the tank command area, redgram is recommended for the entire area, completely replacing the area under ragi. And in well irrigated lands paddy continues to be recommended in all the models.

Table 1. Cropping pattern in the existing plan and varying levels of risk on the upper reach with restricted credit situation in tank command area (acres).

Particulars		Existing plan	Low risk	High risk
A. Kharif Tank irrigated land				
Sandy Loam	(1) Ragi	24.50 (9.23)	21.08 (10.00)	21.08 (8.81)
	(2) Redgram	5.50 (2.07)	-	-
Black Soil	(1) Maize	19.50 (7.34)	22.50 (10.71)	22.50 (9.4)
	(2) Redgram	3.00 (1.13)	-	-
Red Soil	(1) Maize	41.00 (15.44)	41.0 (19.52)	41.0 (17.14)
	Fallow land	-	8.92	8.92
B. Rabi Tank irrigated land				
Sandy Loam	(1) Groundnut	17.50 (6.59)	-	-
	(2) Sunflower	3.50 (1.33)	21.0 (9.99)	21.0 (8.78)
Black Soil	(1) Groundnut	14.00 (3.28)	-	-
	(2) Sunflower	3.00 (1.13)	-	-
Red Soil	(1) Groundnut	31.50 (11.86)	-	-
	(2) Sunflower	4.50 (1.69)	6.75 (3.21)	36.0 (15.05)
	Fallow land	-	46.25	17.0
C. Kharif dryland				
Sandy Loam	(1) Redgram	13.50 (5.08)	89.00 (42.38)	89.00 (37.19)
	(2) Ragi	72.50 (27.31)	-	-
	Fallow land	3.00	-	-
D. Kharif well irrigated land				
Sandy Loam	(1) Paddy	12.00 (4.52)	8.69 (4.51)	13.89 (5.81)
	Fallow land	2.5	3.31	-
Total cropped area		265.50 (100)	210.02 (100)	239.27 (100)
Expected income (E) (million Rs)		0.978	0.775	0.997
Mean absolute deviation (A) (million Rs)		-	0.115	0.161
Standard Deviation (δ) (million Rs)		-	0.161	0.225
Coefficient of variation (cv) (%)		-	2.270	2.448

Figures in parenthesis indicate percentage to the total area.

Table 2. Cropping pattern in the existing plan and varying levels of risk on the middle reach with restricted credit situation in tank command area (acres).

Particulars		Existing plan	Low risk	High risk
A. Kharif Tank irrigated land				
Sandy Loam	(1) Ragi	36.00 (9.11)	15.72 (5.80)	16.66 (5.06)
	(2) Redgram	7.00 (1.77)	22.27 (10.07)	15.30 (4.64)
Black Soil	(1) Maize	24.00 (6.08)	28.00 (10.35)	28.00 (8.5)
	(2) Redgram	4.00 (1.01)	-	-
Red Soil	(1) Maize	54.50 (13.79)	54.50 (20.14)	54.50 (16.55)
	Fallow land	-	-	11.04
B. Rabi Tank irrigated land				
Sandy Loam	(1) Groundnut	31.00 (7.85)	-	-
	(2) Sunflower	7.00 (1.77)	-	22.7 (6.89)
Black Soil	(1) Groundnut	21.00 (5.32)	-	-
	(2) Sunflower	3.50 (0.89)	24.5 (9.06)	24.5 (7.42)
Red Soil	(1) Groundnut	46.00 (11.65)	-	-
	(2) Sunflower	3.00 (0.75)	22.97 (8.48)	49.0 (14.88)
	Fallow land	-	64.03	15.3
C. Kharif dryland				
Sandy Loam	(1) Redgram	18.00 (4.56)	70.58 (26.09)	93.04 (28.25)
	(2) Ragi	122.00 (30.89)	19.55 (7.23)	18.18 (5.52)
	Fallow land	5.00	49.87	28.78
D. Kharif well irrigated land				
Sandy Loam	(1) Paddy	18.00 (4.56)	7.47 (2.76)	7.47 (2.27)
	Fallow land	-	10.53	10.53
Total cropped area		385.00 (100)	270.56 (100)	329.35 (100)
Expected income (E) (million Rs)		1.470	1.098	1.4721
Mean absolute deviation (A) (million Rs)		-	0.178	0.252
Standard Deviation (δ) (million Rs)		-	0.249	0.352
Coefficient of variation (cv) (%)		-	2.267	2.493

Figures in parenthesis indicate percentage to the total area.

Middle reach

The results of the normative cropping pattern in the middle reach of the tank command area are presented in Table 2.

In the Kharif season, in tank irrigated lands, area under ragi is reduced considerably from 36.0 acres to 16.16 acres. Ragi is mainly grown as a food crop as well as a fodder crop. Area under maize did not change in red soils but in black soils however it increased marginally.

In the Rabi season, sunflower was the sole crop to be recommended under low risk, both in black and red soils. At a higher level of risk only sunflower was indicated for sandy loam soils, black soils and red soils. Therefore, when the farmers aspire for higher incomes only, sunflower is to be grown in sandy soils.

Further, in the Kharif dryland areas situated outside the tank command area, redgram is recommended on 93.04 acres and ragi on 18.81 acres. In well irrigated land areas, paddy continues to be recommended.

The income increases only marginally from Rs. 1.47 million to Rs. 1.472 million.

Lower reach

The results for the lower reach is presented in Table 3.

During the Kharif season, area of tank irrigated lands under ragi decreased from 34.05 acres to 21.74 acres and that under maize increased from 27.95 acres to 36.39 acres in red soils. When the level of risk was increased, in sandy loam soils, area under redgram increased significantly to 18.76 acres, whereas the same trend is not observed in the black soils during the Kharif season.

During the Rabi season, the entire area under groundnut in the black soils shifted to the more profitable and less risky sunflower crop in the normative plan. The sandy loam and red soils are completely left fallow. However the farmers have shown a strong tendency to grow groundnut during

Table 3. **Cropping pattern in the existing plan and varying levels of risk on the lower reach with restricted credit situation in tank command area (acres).**

Particulars		Existing plan	Low risk	High risk
A. Kharif Tank irrigated land				
Sandy Loam	(1) Ragi	34.50 (8.65)	21.74 (7.65)	21.74 (6.83)
	(2) Redgram	6.00 (1.50)	18.76 (6.6)	18.76 (5.89)
Black Soil	(1) Maize	25.50 (6.39)	27.50 (9.67)	27.5 (8.63)
	(2) Redgram	2.00 (0.50)	-	-
Red Soil	(1) Maize	53.00 (13.28)	25.95 (9.13)	36.39 (10.83)
	Fallow land	-	27.05	16.61
B. Rabi Tank irrigated land				
Sandy Loam	(1) Groundnut	24.5 (6.14)	-	-
	(2) Sunflower	4.00 (1.00)	-	-
Black Soil	(1) Groundnut	19.50 (4.89)	-	-
	(2) Sunflower	4.00 (1.00)	23.5 (8.27)	23.5 (6.99)
Red Soil	(1) Groundnut	45.50 (11.40)	-	-
	(2) Sunflower	4.50 (1.14)	-	-
	Fallow land	-	78.50	78.5
C. Kharif dryland				
Sandy Loam	(1) Redgram	21.00 (5.26)	152.50 (53.69)	152.50 (45.38)
	(2) Ragi	127.5 (31.95)	-	-
	Fallow land	4.00	-	-
D. Kharif well irrigated land				
Sandy Loam	(1) Paddy	27.50 (6.89)	14.34 (5.04)	8.77 (2.61)
	Fallow land	4.00	13.16	18.75
Total cropped area		399.00 (100)	284.29 (100)	336.07 (100)
Expected income (E) (million Rs)		1.518	0.987	1.269
Mean absolute deviation (A) (million Rs))		-	0.165	0.116
Standard Deviation (б) (million Rs)		-	0.232	0.372
Coefficient of variation (cv) (%)		-	2.349	2.929

Figures in parenthesis ndicate percentage to the total area.

the Rabi season rather than leave the land fallow. This behaviour could be a reflection of the farmers' concern for sustainability as groundnut is a nitrogenous fixing leguminous crop.

In the Kharif dryland areas situated outside the tank command area, red gram is recommended for the entire area, completely replacing the area under ragi. In well irrigated lands paddy continues to be recommended. The income however decreases marginally.

The results of different cropping pattern in the tank command area, *viz.*, upper, middle and lower reaches, indicated alternative cropping patterns and associated risk levels along with the magnitude of net farm returns, from which, the farmers can choose any one of the plans depending upon their attitude towards risk. Similar findings were reported by Ratnam *et al.* (1979) who suggested that through the rational reorganization of resources, the same level of output could be produced by saving a net of 35.65 percent of land. Gajanana and Sharma (1990) identified significant avenues for enhancing the return in all the farm sizes by merely reallocating the resources. The study also indicated that liberal credit and improved technology would increase income prospects and enlarge the employment opportunities.

CONCLUSIONS

A linear approximation of the quadratic programming (MOTAD) was used in deriving risk efficient farm plans. Positive correlation between the magnitude of risk and the levels of net farm returns is confirmed by the study. An observation that can be made based on the results of the study is that the tank command farmers are concerned more about sustainability and less about risk, as the existing cropping pattern had greater diversity and included nutrient fixing crops like groundnut and redgram, whereas, the normative plan suggested more of sunflower. However the farmers were found to be coping with risk by ensuring their domestic requirement of food at least partially, by cultivating ragi. Further the farmers were cultivating groundnut despite being an expensive crop for cultivation rather than sunflower, perhaps to enrich the soil which is indeed commendable from the sustainability stand point of view. Agricultural development should concentrate on supplying resources and new technology for the region. A micro level approach is necessary in the management of small scale reservoirs exposed to risks and uncertainties of farm income by way of optimal crop-mix based on water availability situation.

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