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LAND AND WATER USE POTENTIALS: TUNGABHADRA IRRIGATION PROJECT, MYSORE STATE, INDIA

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16. Abstracts

This study investigated land and water use potentials of the Tungabhadra Irrigation Project (TBP) located in one of the most sparsely settled and impoverished areas of Mysore State, India. Its objectives were to determine the most profitable crops that could be grown on the black soils in the TBP under two alternative sets of land and water use regulations that might be adopted by project officials, and to examine the aggregate crop production potentials and input needs under these alternative sets of regulations. The study was limited to the Fortieth Distributary in the TBP located on the Left Bank Lower Level Canal in the heart of the black soil area.

Four representative farms were identified that are characteristic of the farms in the area studied. For each of the representative farms, 12 constraints were defined: Regulations A and B, concerning irrigated crops allowed; within both A and B, the alternatives of (1) permitting light irrigation only and (2) permitting both light and paddy irrigation; and for each of these four constraints, three situations relative to credit and land developed for irrigation. Linear programming was used to find the crop combinations that would maximize net income under 12 situations for each of the representative farms.

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SUMMARY

This study investigated land and water use potentials of the Tungabhadra Irrigation Project (TBP) located in one of the most sparsely settled and impoverished areas of Mysore State, India. Its objectives were to determine the most profitable crops that could be grown on the black soils in the TBP under two alternative sets of land and water use regulations that might be adopted by project officials, and to examine the aggregate crop production potentials and input needs under these alternative sets of regulations. The study was limited to the Fortieth Distributary in the TBP located on the Left Bank Lower Level Canal in the heart of the black soil area.

Four representative farms were identified that are characteristic of the farms in the area studied. For each of the representative farms, 12 constraints were defined: Regulations A and B, concerning irrigated crops allowed; within both A and B, the alternatives of 1) permitting light irrigation only and 2) permitting both light and paddy irrigation; and for each of these four constraints, three situations relative to credit and land developed for irrigation. Linear programming was used to find the crop combinations that would maximize net income under 12 situations for each of the representative farms.

The highlights of the findings are:

1) When credit was limited and irrigable acres restricted to that presently developed, a dryland cropping system would produce more net farm income than irrigated crops under the land and water use regulations examined with one exception. Growing cotton and paddy on part of the authorized irrigable acres would provide more income on large farms. Credit limitation is an important reason why farmers, particularly those with small and medium size farms, are slow to develop land for irrigation.

2) When the credit restraint was removed and the irrigable acres restricted to that presently developed, optimum cropping patterns would change under both sets of land and water use regulations. Crops that had the highest net income per acre, rather than the highest net income per rupee invested, would maximize net farm income. Higher net incomes would be earned by using all the cultivable acres and shifting from dryland cotton to dryland *jowar*. On the larger farms, farmers would double-crop developed land

to the extent of the authorized irrigable acres permitted. Maximum use would be made of the land presently developed for irrigation.

3) When both credit and irrigable acres were not constraints, it would pay farmers to grow a greater assortment of crops than when credit was limited or unlimited and the irrigable acres restricted to that presently developed. Thus, with adequate credit and irrigable acres, farmers would use their water and acres authorized for irrigation to best advantage. Farmers under these conditions would find it profitable to give top priority to irrigated crops.

4) When the credit and irrigable acres constraints were eased, net farm income would increase in every situation. The increase was proportionally greater for the smaller farms than for the larger ones. This was true under both sets of regulations and whether or not paddy was permitted. Total cultivable acres per farm, the acreage developed for irrigation, and the amount of credit used were all positively related to net income.

5) When credit was unlimited and the irrigable acres restricted to that presently developed, the value of crop production in excess of cash inputs for the distributary would be 8.1 percent greater if Regulations B were put into effect rather than Regulations A. Under Regulations B, 3.5 percent more land would be cropped in the distributary, 27 percent fewer irrigable acres would be required to maximize farmers' net incomes, and one-third more land would be double-cropped. Total cultivable acres used would be the same under both sets of regulations.

6) When both credit and irrigable acres were not constraints, the value of crop production in excess of cash inputs would be 8.8 percent more under Regulations B than Regulations A. Six percent more acres would be cropped in the distributary operating under Regulations B and A. Forty-four percent more irrigable acres would be used under Regulations A, but 51 percent more acres would be double-cropped under B.

7) When credit was either limited or unlimited and the irrigable acres constraint removed, the gross value of crop production would increase under both sets of regulations. The values would be greater under Regulations B and A.

Thus, in order to maximize net farm income from crop produc-

tion in the distributary under the constraints examined, TBP officials should implement Regulations B, make provisions for unlimited credit and land developed for irrigation, and permit irrigation for both light irrigated crops and paddy.

The regulations suggested can be implemented with a minimum of technical equipment and trained personnel. Any system of regulations, however, will be difficult to enforce. Consequently, it is absolutely essential that the farmers concerned understand the basic regulations and reasons for complying with them. Local support for the program is the key to its successful operation.

CONTENTS

Land and Water Use Potentials: Tungabhadra Irrigation Project, Mysore State, India[1]

by M. B. Badenhop and Parker D. Cashdollar*

The Tungabhadra Irrigation Project (TBP) is located in one of the most sparsely settled and impoverished areas of South India. The area's annual rainfall of 20 inches is maldistributed with less than 15 percent falling in the period, November through April.[2] As a result, serious drought occurs annually. The Tungabhadra Dam was completed in 1953 to provide irrigation water for the area. Since that time, the water distribution system has been in various stages of development. The TBP is planned to irrigate 1,272,404 acres through three major canal channels and their distributaries, making it one of the largest irrigation projects in South India.[3] Two soil groups are dominant in the project area: black clay soils and red loam soils.[4]

THE PROBLEM

As sections of the distributary system were completed, it became apparent that farmers were slow to develop land and under-

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[1]The study reported was conducted in early 1971 in collaboration with R. Ramanna, Donald C. Taylor, and other agricultural economists at the Mysore University of Agricultural Sciences, Bangalore, India. The authors acknowledge extensive assistance from David W. Brown for comments and suggestions.

[2]April and May are the hottest months with mean maximum temperatures averaging 100.6 degrees Fahrenheit and mean daily temperatures averaging 89.2 degrees. December is the coolest month with daily temperatures averaging 73.7 degrees Fahrenheit.

[3]C. M. Revanna, "Development of TBP Ayacut in Raichur and Bellary Districts," in *Tungabhadra: A Citadel of Hope*, Narasing Rao Madarkal (ed.) (Bangalore: The Department of Information and Tourism, 1968), pp. 29-31.

[4]B. V. Vankata Rao, *Soil Recources of Mysore* (Bangalore: Mysore University of Agricultural Science, 1968), pp. 3-5.

The black clay soils, also called black cotton soils, contain 40 to 50 percent clay and have a high moisture-holding capacity. Their pH generally ranges from seven to nine and they are well supplied with calcium, magnesium, and potassium. Organic matter, nitrogen, and phosphorus contents are low. These soils shrink and swell and develop large cracks during dry periods. Their main advantages are their water retentive capacity and their structure which holds deep percolation to a minimum in paddy (rice) cultivation. Their main limitations are their high bulk density and their tendency toward alkalinity and salinity.

take irrigation, particularly in the black soil areas.[5] To encourage the development of these areas, land and water regulations were relaxed during the early stages of the project to allow all farmers to grow paddy on land originally authorized for only light irrigation.[6] Other crops used less water than paddy, but were less attractive to farmers. In 1967, this concession was withdrawn, but by then farmers were accustomed to growing paddy and were not willing to comply with the new rules.

This situation points to the need for TBP officials to have better information about likely farmer responses and production effects when deciding what land and water use constraints to impose. Therefore, this study was undertaken 1) to determine the combination of crops that would maximize net returns to farmers on the black soils in the area under alternative sets of land and water use regulations that might be adopted by project officials, and 2) to examine the aggregate crop production potentials and input needs under these alternative sets of regulations. The study was limited to the Fortieth Distributary comprising 31,540 acres in the TBP.[7]

The red soils are loamy in texture and contain 10 to 20 percent clay, are well drained, and easy to cultivate. Most crops grow well on the red soils. When used for paddy cultivation, the red soils have deep percolation losses relative to the black soils.

[5]Jayakumar Anagol, "A Strategy for Ayacut Development Under Major Irrigation Projects," in *Tungabhadra Project Achievements and Aspirations, 1970*, Narasing Rao Madarkal (ed.) (Bangalore: The Government Press, 1970), p. 60.

Developed land refers to land developed for irrigation, either for paddy or for crops authorized for only light irrigation.

Land in the black soil areas was being developed for irrigation much slower than expected where paddy was permitted and virtually not at all where only light irrigated crops could be grown. In the red soils areas, land restricted to light irrigation developed for irrigation as rapidly as the land on which only paddy could be grown. The rate was still slower than expected.

[6]Light irrigation means that most of the available water is used for "light" irrigated crops, such as wheat, cotton, and *jowar*, rather than for "heavy" irrigation of paddy. A general rule of thumb is that roughly three times as much water is required to grow an acre of paddy than an acre of the light irrigated crops.

[7]No detailed soil survey of the TBP has been made. For the purpose of this study, the black soils of the Fortieth Distributary are assumed homogeneous. The black clay soils comprise about 80 percent of the soils in the distributary.

(Footnote [7] continued on page 8)

This is located on the Left Bank Lower Level Canal in the heart of the black soil area (Figure 1).[8]

METHODOLOGY

Land and Water Use Regulations

Two sets of land and water use regulations for allocating water were investigated:[9]

1) *Regulations A:* Lands authorized for paddy would receive water from June through November at a rate adequate for paddy. *Kharif* (fall cropping season) lands would receive water adequate for light irrigated crops for four months, June through September. Cotton lands would receive water adequate for cotton, or for the light irrigated *rabi* (winter cropping season) crops, for six months from August through January. [10]

2) *Regulations B:* Similar to Regulations A, except *rabi* lands would receive water from November through February rather than from October through January. Unlike Regulations A, cotton allocations would not be used because cotton is planted about September 1 and does not need irrigation during September, the month of heaviest rainfall. During October, cotton generally requires little irrigation. Its needs can be met easily because neither *kharif* nor *rabi* crops will require water in October. The dates for receiving water are the same for *kharif* and paddy authorizations as they were in Regulations A.

On the Fortieth Distributary, as in all distributaries, paddy lands are authorized in blocks. These paddy blocks contain from 100 to 600 acres of contiguous lands that are in basins or lower elevations. The standing water in paddy fields causes adjacent lands to become waterlogged and salt damaged.

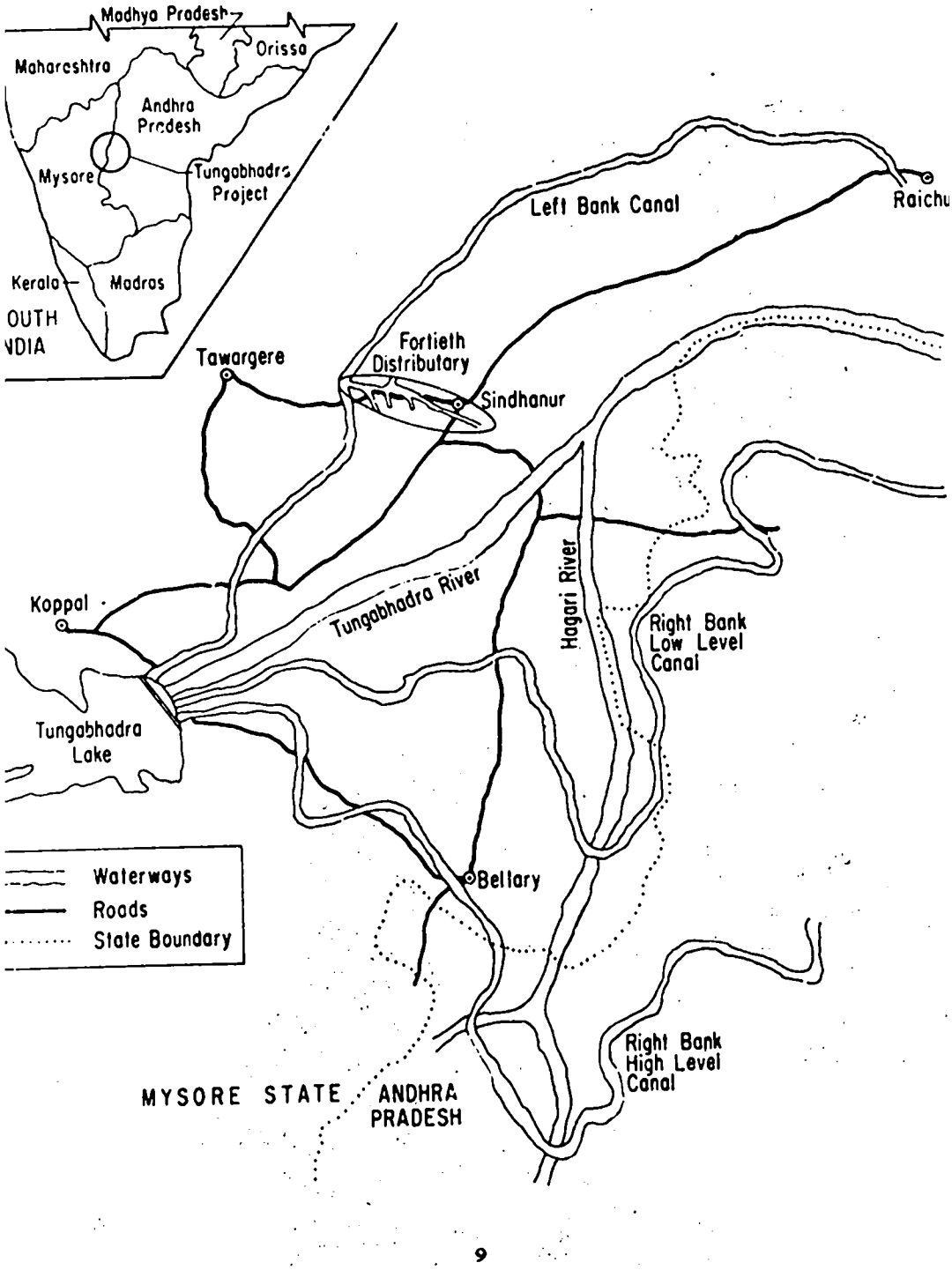
There are three paddy blocks on the Fortieth Distributary of about 200 acres each, comprising 677 acres. The relatively small number of acres allocated for paddy and its authorizations in blocks means that most farmers do not have acreage allocated for paddy.

[8]The Left Bank Lower Level Canal is 141 miles long and lies entirely in Raichur District of Mysore State. It is designed to irrigate 580,000 acres.

[9]State of Mysore, Public Works Department, *Distributarywise Localization Statement for Distributaries 36 to 56* (Sindhanur: Public Works Department), an unpublished bulletin, 1969. These regulations (called localizations in India) specify the types of crops that each farmer can grow, how many acres, and in what seasons.

[10]Land authorized for light irrigation is categorized as *kharif*, *rabi*, or cotton land. *Kharif*, or "fall" cropping season, roughly corresponds to the June through September period. *Rabi*, or "winter" cropping season, roughly corresponds to the October through January period. Cotton has a six-month duration and is often called "*kharif-rabi*" crop because it overlaps both seasons.

Figure 1. The Tungabhadra Irrigation Project Area.



Acreages assumed under Regulations A and B in this study were calculated on the basis of technical estimates of a) irrigation water requirements of the major crops, and b) the available water flows. The main water constraints were 1) the quantity of water and the time periods during which it was available, and 2) the carrying capacity of the channels on the distributary. The land and water use regulations served as a guide to determine the number of acres assigned to each category.[11] The results are given in Table 1.

Table 1. Acres assumed under irrigation for the Fortieth Distributary by type of regulation and by season, Tungabhadra Irrigation Project, Mysore State, India, 1970

Irrigation schedule	Under Regulations A	Under Regulations B
	Acres	
Paddy (June-November)	677	677
Kharif (June-September)	6,044	6,399
Rabi (October-January)	4,739	—
Rabi (November-February)	—	6,399
Cotton (August-January)	2,370	—
Total	13,830	13,475

The Representative Farms

One hundred sixteen farmers who owned land authorized for irrigation in the Fortieth Distributary were randomly selected and interviewed to determine the resources they had available for crop production. Four representative farms were then identified from the data collected.[12] The key difference among these farms was size in terms of acres developed for irrigation. Other resource constraints considered were total cultivable acres, family labor supply, owned bullock power, cash on hand, and personal debts. The values of these resources for the representative farms are given in Table 2.

A review of the acreage allocated for paddy production in the distributary showed that about one-tenth (9.8 percent) of the farmers had land under deeds with specific authorization to grow

[11] *A Guide for Estimating Irrigation Water Requirements* (New Delhi: The Government Press, 1970).

[12] There are 1,443 farms on the distributary. Of these, 16 percent are typified by Representative Farm 1; 41 percent by Representative Farm 2; 22 percent by Representative Farm 3; and 21 percent by Representative Farm 4.

Table 2. Assumed resources of representative farms for the Fortieth Distributary, Tungabhadra Irrigation Project, Mysore, State, India, 1970

Resources[a]	Unit	Farm 1	Farm 2	Farm 3	Farm 4
Total cultivable land[b]	Acres	11.8	14.2	26.7	39.3
Land developed for irrigation	Acres	0	2.0	4.7	14.6
Family labor available per month[c]	Man-hours	561	755	655	760
Owned bullock power available per month[d]	Bullock pair hours	208	229	279	438
Cash on hand	Rupees[e]	12	36	223	1,383
Present debts	Rupees	631	1,038	2,330	1,914

[a]The average situations found for the farmers surveyed when the farms were sorted into four size groups based upon acres developed for irrigation.

[b]Approximately 10 percent of total land was wasteland and is not included in these figures.

[c]Men and women in the labor force were available to work 250 hours each per month. Child labor was not included in the labor force even though children performed certain miscellaneous activities. Each hour of work supplied by women was assumed to be equivalent to four-fifths of a man-hour.

[d]Bullock power was considered the only source of draft power used in the study. Bullock pairs on the representative farms were assumed to be available 250 hours per month. Multiplying the bullock pairs available by 250 gave the bullock pair hours available per month.

[e]One U. S. dollar is equal to 7.5 rupees (Rs.).

paddy. Thus, when the land and water use authorizations were made for each representative farm, it was necessary to consider two irrigation alternatives. Under the first alternative (light irrigation only), only light irrigation was permitted. This alternative was characteristic of the same 90 percent of all farms in the distributary that did not have acreage authorized for paddy. The second alternative (both light and paddy irrigation) applied only to the remaining 10 percent that had acreage on which paddy could be grown. Thus, eight assumed situations for each set of regulations on land and water use were examined—one for each representative farm operating under light irrigation only and one for each representative farm operating under both light and paddy irrigation. For each situation, the combination of crops that would maximize net returns to farmers was determined and the results were aggregated to estimate production potentials and input needs in the distributary. The acres authorized for irrigation under each alternative are given in Table 3.

Credit and Land Developed For Irrigation Situations Considered

Three situations concerning the amount of credit and land developed for irrigation were also considered for each farm. In the first situation, one with limited credit, it was assumed that operating credit was available to farmers in an amount not to exceed their present indebtedness.[14] In the second situation, operating credit was unlimited to all farmers. In these two situations, land available for irrigation was restricted to that presently developed. In the third situation, it was assumed that credit was unlimited and that irrigable acres was not a constraint.

Linear Programming Used

Farm activities considered: Thus, for purposes of this analysis, 12 sets of constraints were defined for each of the four representative farms—Regulations A and B, concerning irrigated crops allowed; within both A and B, the alternatives of 1) permitting light irrigation only, and 2) permitting both light and paddy irrigation; and for each of these four constraints, three situations relative to credit and land developed for irrigation.

[14] An exception to this constraint was that Representative Farm 4 was allowed credit up to Rs. 4,000 rather than the amount of its present indebtedness. The resources on this farm were adequate to justify this exception.

Table 3. Acres authorized for irrigation on the representa.ive farms under two sets of land and water use regulations, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India, 1970

Crop irrigation authorizations	Farm 1 (11.8 A)[a]		Farm 2 (14.2 A)[a]		Farm 3 (26.7 A)[a]		Farm 4 (39.3 A)[a]	
	Light irr. only	Both light & paddy irr.	Light irr. only	Both light & paddy irr.	Light irr. only	Both light & paddy irr.	Light irr. only	Both light & paddy irr.
	Acres							
Regulations A								
Paddy	—	2.6	—	3.1	—	5.9	—	8.6
Kharif	2.4	1.2	2.9	1.4	5.4	2.7	7.9	4.0
Rabi	1.9	.9	2.2	1.1	4.2	2.1	6.2	3.1
Cotton	.9	.5	1.1	.6	2.1	1.0	3.1	1.5
Total	5.2	5.2	6.2	6.2	11.7	11.7	17.2	17.2
Regulations B								
Paddy	—	2.6	—	3.1	—	5.9	—	8.6
Kharif	2.5	1.2	3.05	1.5	5.75	2.8	8.4	4.1
Rabi	2.5	1.2	3.05	1.5	5.75	2.8	8.4	4.1
Total	5.0	5.0	6.1	6.1	11.5	11.5	16.8	16.8
Number of farms[b]	202	22	539	58	292	31	270	29

[a]Total cultivable acres.

[b]The number of farms in each irrigation alternative is the cofficient used for aggregating to show total distributary production and input needs. The representative farm of each size group is identical except for the irrigation alternative. Under both alternatives, each representative farm has the same number of acres authorized for irrigation. However, half of the authorized acres is for paddy on those farms where both light and paddy irrigation is permitted.

Linear programming was used to find the crop combinations that would maximize net income on each representative farm under each of the assumed situations. Net income was defined as the returns to family labor, land, management, and capital invested in bullocks and implements. The crops included as income-generating activities were limited to crops previously grown locally that were considered profitable by farmers and by agricultural specialists familiar with the area. These crops were paddy (rice), *jowar* (sorghum), wheat, *navane* (foxtail millet), *bajra* (pearl millet), cotton, and safflower.[14] Three "buying" activities were also included: hiring labor, hiring bullocks, and borrowing operating capital. Flexibility to use "paddy land" for the light irrigated crops and to use "cotton land" for *rabi* crops was also built into the analysis. Double-cropping activities were combinations of the single crops permitted by the authorizations and which were technically feasible.

Input-output coefficients: The input-output and cost-return data used to synthesize the crop budgets were derived from several sources. These included information from the Fortieth Distributary farm survey; interviews with personnel of the Mysore University of Agricultural Sciences, Mysore State Department of Agriculture, and the U. S. Agency for International Development sponsored specialists; and relevant agronomic and farm management reports.[15] Only one input and output level was allowed for each crop. This level was defined as an output level that a farmer could reasonably expect to obtain if he used the recommended cultural practices, adequate irrigation water (or normal rainfall under dryland conditions), and the recommended fertilizer rates. Hired labor and hired bullock power was assumed

[14]Several crops grown on the black soils were not considered in the analysis because farmers in the area and researchers did not consider them as among the more profitable crops and because markets for such crops were not well established. These crops include the pulse crops, castor, coriander, groundnut (peanut), and perishable vegetable crops. Some farmers, however, specialize in their crops. Likewise, mixed cropping, the growing of two or more crops in the same row or in alternate rows in the same field, was not considered in the analysis. With irrigation becoming more prevalent, mixed cropping will be less important.

[15]Two recent farm management studies that were especially helpful were: 1) S. Bisaliah and Donald C. Taylor, *An Economic Analysis of Major Irrigated Crops in the Tungabhadra Irrigation Project* (Bangalore: Mysore University of Agricultural Sciences, and unpublished bulletin, 1971), and 2) C. Nanja Reddy, K. C. Hiremath, and Estel H. Hudson, *Farm Planning Manual* (Bangalore: Mysore University of Agricultural Sciences, an unpublished bulletin, 1970).

available in unlimited amounts at the current daily wage rate. Input prices used were those prevailing (February 1971) in the distributary. Output prices were average prices for 1970 at the Raichur regulated market, which serves the area.

The crops considered, net income per acre, cash expenses per acre, expenses, and the net income per rupee of cash expense are shown in Table 4.

Table 4. Net income per acre, cash expenses per acre, and net income per rupee of cash expense for selected crops, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India, 1970

Crop	Net income per acre	Cash expenses per acre	Net income per rupee of cash expense
	Rupees		
Dryland crops			
Rabi cotton	266	69	3.8
Rabi safflower	271	78	3.4
Rabi wheat	140	134	1.0
Rabi jowar (grain sorghum)	301	111	2.7
Irrigated crops			
Kharif paddy	787	350	2.2
Kharif jowar	550	277	2.0
Kharif bajra (pearl millet)	331	222	1.5
Kharif or rabi navane (foxtail millet)	287	217	1.3
Kharif-rabi cotton	720	251	2.9
Rabi jowar	554	274	2.0
Rabi safflower	535	167	3.2
Rabi wheat	660	335	2.0

RESULTS

Tables 5 through 10 summarize the farm level and aggregate results obtained from the linear programming analysis as it was applied to the data collected for the Fortieth Distributary. Only the highlights of the findings and their implications will be discussed.

1. Tables 5 and 6, Crops That Would Be Grown to Maximize Income Under Regulations A and B

Credit limited and irrigable acres restricted: To maximize net income when credit was limited and irrigable acres restricted to those presently developed, dryland cotton would be the predominant crop grown on all representative farms under each irriga-

tion alternative in both sets of land and water use regulations. This was most apparent for Representative Farm 1, typical of the smaller farms. On Farm 1, 79 percent of the available cultivable acres was used for crop production and the only crop grown was dryland cotton.[16]

With limited credit, farmers with acreage greater than those typical of Farm 1 could use only a part of their authorized irrigable acres for growing irrigated crops. The larger the farm, the greater was the proportion of authorized irrigable acres used. This relationship is illustrated by Farm 4 and to a lesser extent by Farm 3. Cotton would be the predominant irrigated crop grown under these conditions—particularly on farms that did not have acreage authorized for growing paddy. The larger farms represented by Farm 4, which had acreage authorized for growing paddy, used only a third of such acreage.

In general, cropping combinations that would maximize net income when credit and land developed for irrigation were limited would be similar under both sets of regulations and irrigation alternatives. Total cultivable acres in the distributary would not be utilized to the extent they could be and considerable irrigable acres would not be used. When credit and developed land were limited to this extent, the choices depend upon those crops that have the highest net income per rupee of expense rather than net income per acre. Limitation of credit may be an important reason why farmers in the area, particularly those with small farms, are slow to develop land for irrigation.[17]

Credit unlimited and irrigable acres restricted: When the credit restraint was lifted, cropping patterns changed under each irrigation alternative in both sets of regulations. Higher net incomes per farm were earned by using all the cultivable acres and shifting mainly from dryland cotton to dryland *jowar*. In fact, *jowar* was the only dryland crop grown. Net incomes were maximized by growing the crops that had the highest net income per acre rather than the highest net income per rupee invested.

On the small farms, represented by Farm 1, which had no land developed for irrigation, net incomes were maximized by growing dryland *jowar* on all the cultivable acres. On the middle-sized farms, those represented by Farms 2 and 3, farmers double-cropped land developed for irrigation to the extent their authorized

[16]In this and subsequent sections, the farming patterns described are not what farmers actually were doing when surveyed in 1971, but what they *would* have done if they had followed the linear programming results.

[17]The cost of developing land for irrigation is approximately Rs. 500 per acre.

Table 5. Crop combinations that would maximize net income under three credit and land developed for irrigation situations for representative farms under Regulations A, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India

Crops that would be grown to maximize net income, Regulations A[c]	Farm 1 (11.8 A)[a]			Farm 2 (14.2 A)[a]			Farm 3 (26.7 A)[a]			Farm 4 (39.3 A)[a]		
	(1)[b]	(2)[c]	(3)[d]	(1)[b]	(2)[c]	(3)[d]	(1)[b]	(2)[c]	(3)[d]	(1)[b]	(2)[c]	(3)[d]
	Acres											
Light irrigation only:												
Dryland cotton	9.3	—	—	13.7	—	—	18.0	—	—	27.3	—	—
Dryland jowar	—	11.8	8.5	—	12.2	10.1	—	22.0	18.1	—	25.8	25.8
Irrigated kharif jowar	—	—	—	—	—	—	—	—	2.3	—	4.2	4.2
Irrigated cotton	—	—	.9	.4	—	1.1	4.6	—	2.1	9.3	3.1	3.1
Irrigated rabi wheat	—	—	—	—	—	.1	—	—	1.1	—	2.5	2.5
Irrigated rabi safflower	—	—	—	.1	—	—	—	—	—	—	—	—
Irrigated kharif bajra and dryland jowar	—	—	.5	—	—	.8	—	—	—	—	—	—
Irrigated kharif bajra and rabi wheat	—	—	1.9	—	2.0	2.1	—	4.7	3.1	—	3.7	3.7
Both light and paddy irrigation:												
Dryland cotton	9.3	—	—	13.7	—	—	20.9	—	—	24.3	—	—
Dryland jowar	—	11.8	7.6	—	12.2	9.1	—	22.0	17.1	3.8	24.7	24.1
Dryland safflower	—	—	—	—	—	—	—	—	—	4.0	—	—
Paddy	—	—	2.6	—	.3	3.1	—	1.5	5.9	2.6	8.6	8.6
Irrigated cotton	—	—	.5	.4	—	.6	3.2	—	1.0	4.6	1.6	1.6
Irrigated rabi wheat	—	—	—	—	—	—	—	—	—	—	.4	1.1
Irrigated rabi safflower	—	—	—	.1	—	—	—	—	—	—	—	—
Irrigated kharif bajra and dryland jowar	—	—	.2	—	—	.3	—	—	.6	—	1.3	1.9
Irrigated kharif bajra and rabi wheat	—	—	.9	—	1.7	1.1	—	3.2	2.1	—	2.7	2.0

[a]Total cultivable acres.

[b]Credit limited and irrigable acreage restricted to that presently developed.

[c]Credit unlimited and irrigable acreage restricted to that presently developed.

[d]Credit unlimited and irrigable acres unrestricted.

[e]Double-cropping activities included were combinations of the single crops permitted by the authorizations and which were technically feasible. The activities were various combinations of irrigated *kharif*, irrigated *rabi*, and dryland *rabi* crops.

Table 6. Crop combinations that would maximize net income under three credit and land developed for irrigation situations for representative farms under Regulations B, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India

Crops that would be grown to maximize net income, Regulations B[c]	Farm 1 (11.8 A)[a]			Farm 2 (14.2 A)[a]			Farm 3 (26.7 A)[a]			Farm 4 (39.3 A)[a]		
	(1)[b]	(2)[c]	(3)[d]	(1)[b]	(2)[c]	(3)[d]	(1)[b]	(2)[c]	(3)[d]	(1)[b]	(2)[c]	(3)[d]
	Acres											
Light irrigation only:												
Dryland cotton	9.3	—	—	13.3	—	—	19.9	—	—	30.2	—	—
Dryland jowar	—	11.8	9.3	—	12.2	11.7	—	22.0	21.0	—	30.9	30.9
Dryland safflower	—	—	—	—	—	—	—	—	—	.7	—	—
Irrigated cotton	—	—	—	—	—	—	4.0	—	—	7.6	—	—
Irrigated rabi safflower	—	—	—	.9	—	—	—	—	—	—	—	—
Irrigated kharif jowar and irrigated rabi wheat	—	—	2.5	—	2.0	3.05	—	4.7	5.75	.8	8.4	8.4
Both light and paddy irrigation:												
Dryland cotton	9.3	—	—	13.3	—	—	21.6	—	—	25.5	—	—
Dryland jowar	—	11.8	8.0	—	12.2	9.6	—	22.0	18.0	4.9	26.6	26.6
Dryland safflower	—	—	—	—	—	—	—	—	—	1.9	—	—
Paddy	—	—	2.6	—	.5	3.1	.5	1.9	5.9	2.9	8.6	8.6
Irrigated cotton	—	—	—	—	—	—	2.8	—	—	4.1	—	—
Irrigated rabi safflower	—	—	—	.9	—	—	—	—	—	—	—	—
Irrigated kharif jowar and irrigated rabi wheat	—	—	1.2	—	1.5	1.5	—	2.8	2.8	—	4.1	4.1

[a]Total cultivable acres.

[b]Credit limited and irrigable acreage restricted to that presently developed.

[c]Credit unlimited and irrigable acreage restricted to that presently developed.

[d]Credit unlimited and irrigable acres unrestricted.

[e]Double-cropping activities included were combinations of the single crops permitted by the authorizations and which were technically feasible. The activities were various combinations of irrigated *kharif*, irrigated *rabi*, and dry-land *rabi* crops.

kharif and *rabi* acreage in combination allowed. Paddy was not grown to the extent authorized on these farms because the light irrigated crops in double-cropping combinations yielded higher net income per acre than any single crop, including paddy. On the larger farms, represented by Farm 4, the irrigable acres presently developed were adequate to maximize net incomes given the resources these farms had. All land authorized for growing paddy was so utilized where the irrigation alternative permitted it. This indicates for the larger farms that it was not profitable to trade paddy land for *kharif*, trade cotton for *rabi*, or to combine them and double-crop the light irrigated crops.

The primary difference in the optimum cropping pattern between Regulations A and B when credit was limited and unlimited and when the irrigable acreage was restricted was due to differences in the farmers' ownership of *kharif* and *rabi* acres authorized for irrigation. In Regulations B, farmers owned equal *kharif* and *rabi* irrigable acres that could be combined and used for double-cropping. Also, the four-month *kharif* crops could be double-cropped and thus, maximum use could be made of the irrigable acres. In Regulations A, where *kharif* and *rabi* acres authorized for irrigation were not equal, a greater variety of crops could be grown, but fewer acres could be double-cropped.

Credit unlimited and irrigable acres unrestricted: When both credit and irrigable acres were not constraints, the results show what is most likely to happen when the distributary is fully developed. Although land development in the TBP has been slower than project officials would like, there is reason to believe that enough land will be developed eventually to use all irrigation water. The shortages of water that have already been reported in parts of the project area indicate that enough land may already be developed on some of the distributaries.

The term "fully" developed, as used in the TBP area, originally meant development of all the authorized irrigable acres. Results show when credit and developed land were not constraints, and with double-cropping becoming popular, that there may be no need for "fully" developing the distributary. The term "fully" developed is most meaningful when reference is to the development of enough land to use all the irrigation water available. The early planners of the TBP did not anticipate that double-cropping of irrigated crops would be practiced to a great extent. Thus, it is difficult to predict how many irrigable acres will be developed. The amount of land ultimately developed will depend greatly on the land and water use regulations that are adopted.

When both credit and developed land were not constraints, farmers, in order to maximize net income, grew the crops which yielded the highest net income per acre rather than those that yielded the greatest net income per rupee of cash expense.

A comparison of cropping patterns, operating under Regulations A, when credit was unlimited and irrigable acres restricted with the situation when both credit and irrigable acres were not restricted, shows—except for Farm 4, representative of the larger farms—that a greater assortment of crops was grown in the situation where both credit and developed land for irrigation were not restricted. For the larger farms, the assortment of crops grown was the same in both situations. This indicates that enough developed land provided farmers greater opportunity to utilize their irrigation authorizations to maximum advantage.

Under both Regulations A and B, when there were no restraints on credit and land developed for irrigation and when paddy was permitted, all acreage authorized for paddy production was used. Under Regulations A, cropping patterns varied considerably among the representative farms, but under Regulations B they were essentially the same. Under Regulations B, farmers took advantage of double-crop combinations to the extent permitted by acreage authorized for irrigation. Farmers under these conditions found it feasible and profitable to give top priority to irrigated crops.[18] Also, under Regulations B, slightly more dryland *jowar* would be grown than under Regulations A because the combining of *kharif* and *rabi* allocations for double-cropping released land for dryland cropping.

General observations in the TBP area, as well as interviews with farmers and project officials, indicate clearly that paddy was the most popular crop at the time of the 1971 survey. In fact, nearly all the developed land was being used for paddy production. This was mainly because existing regulations on allocation of water were not being enforced. Farmers, in general, were double-cropping *kharif* paddy followed by a summer crop of paddy or following the *kharif* paddy with light irrigated crops of wheat and safflower. The double-cropping systems using paddy yielded higher net income per acre of developed land than any double-cropping

[18]Crops that would not be grown under the land, water, and capital constraints examined are dryland wheat, irrigated *rabi jowar*, and irrigated *navane* in either the *kharif* or *rabi* season. Because these crops were not grown does not mean they are not profitable. It means they were not as profitable in the representative farm situations as the crops that were grown. Since all the farm situations found in the distributary were not included in the analysis, it is possible that these crops will be grown to a limited extent in the TBP.

combination of light irrigated crops. Since water was virtually free to the individual farmers, they were not concerned with the fact that paddy requires much more water per acre than the other crops.

2. **Tables 7 and 8, Net Income, Irrigable Acres, and Credit Used**

Net income increased in every situation when credit and the irrigable acres constraints were eased. The increase was proportionally greater for the smaller farms than for the larger ones. This was true under both sets of land and water use regulations examined and whether or not paddy was permitted. Total cul-

Table 7. Potential net income, irrigable acres used, and credit used on the representative farms under Regulations A and two irrigation alternatives, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India

Regulations A	Farm 1 (11.8 A)[a]	Farm 2 (14.2 A)[a]	Farm 3 (26.7 A)[a]	Farm 4 (39.3 A)[a]
		Net income (Rs.)		
Light irrigation only:				
Cr. ltd. & irr. A res.	2,217	3,754	7,361	13,049
Cr. unltd. & irr. A res.	3,046	5,505	9,336	15,167
Cr. unltd. & irr. A unres.	4,470	5,805	10,026	15,167
Both light and paddy irrigation:				
Cr. ltd. & irr. A res.	2,217	3,754	7,302	12,512
Cr. unltd. & irr. A res.	3,046	5,005	9,188	15,914
Cr. unltd. & irri. A unres.	4,773	6,168	10,514	15,921
		Irrigable land used (acres)		
Light irrigation only:				
Cr. ltd. & irr. A res.	n. a.[b]	.5	4.6	9.3
Cr. unltd. & irr. A res.	n. a.	2.0	4.7	13.5
Cr. unltd. & irr. A unres.	3.3	4.1	8.6	13.5
Both light and paddy irrigation:				
Cr. ltd. & irr. A res.	n. a.	.5	3.2	7.2
Cr. unltd. & A res.	n. a.	2.0	4.7	14.6
Cr. unltd. & irr. A unres.	4.7	5.1	9.6	15.2
		Credit used (Rs.)		
Light irrigation only:				
Cr. ltd. & irr. A res.	631	1,038	2,330	4,000
Cr. unltd. & irr. A res.	1,300	2,426	5,438	7,613
Cr. unltd & irr. A unres.	2,381	2,843	5,648	7,613
Both light and paddy irrigation:				
Cr. ltd. & irr. A res.	631	1,038	2,330	4,000
Cr. unltd. & irr. A res.	1,300	2,364	5,048	8,660
Cr. unltd. & irr. A unres.	2,461	2,937	6,260	8,654

[a]Total cultivable acres.
[b]n.a. = not applicable.

Table 8. Potential net income, irrigable acres used, and credit used on the representative farms under Regulations B and two irrigation alternatives, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India

Regulations B	Farm 1 (11.8 A)[a]	Farm 2 (14.2 A)[a]	Farm 3 (26.7 A)[a]	Farm 4 (39.3 A)[a]
		Net income (Rs.)		
Light irrigation only:				
Cr. ltd. & irr. A res.	2,217	3,775	7,474	13,192
Cr. unltd. & irr. A res.	3,046	5,457	10,119	16,496
Cr. unltd. & irr. A unres.	4,841	6,285	10,762	16,496
Both light and paddy irrigation:				
Cr. ltd. & irr. A res.	2,217	3,775	7,426	12,532
Cr. unltd. & irr. A res.	3,046	5,277	9,631	13,460
Cr. unltd. & irr. A unres.	4,935	6,396	10,885	16,460
		Irrigable land used (acres)		
Light irrigation only:				
Cr. ltd. & irr. A res.	n. a.[b]	.9	4.0	8.4
Cr. unltd. & irr. A res.	n. a.	2.0	4.7	8.4
Cr. unltd. & irr. A unres.	2.5	3.0	5.7	8.4
Both light and paddy irrigation:				
Cr. ltd. & irr. A res.	n. a.	.9	3.3	7.0
Cr. unltd. & irr. A res.	n. a.	2.0	4.7	12.7
Cr. unltd. & irr. A unres.	3.8	4.6	8.6	12.7
		Credit used (Rs.)		
Light irrigation only:				
Cr. ltd. & irr. A res.	631	1,083	2,330	4,000
Cr. unltd. & irr. A res.	1,300	2,536	5,847	8,791
Cr. unltd. & irr. A unres.	2,540	3,071	6,462	8,791
Both light and paddy irrigation:				
Cr. ltd. & irr. A res.	631	1,083	2,300	4,000
Cr. unltd. & irr. A res.	1,300	2,405	5,178	8,969
Cr. unltd. & irr. A unres.	2,540	3,031	6,455	8,969

[a]Total cultivable acres.
[b]n.a. = not applicable.

tivable acres per farm, the irrigable acreage, and the amount of credit used were all positively related to net income. To illustrate these relationships, the results for Representative Farm 1, typical of the smaller farms, and for Representative Farm 4, typical of the larger farms, were examined under the assumption that Regulations A would be in force and that paddy was permitted as a crop.

For the typical small farm (Representative Farm 1) with credit limited to present indebtedness, Rs. 631, and irrigable acres restricted to that presently developed (none on the small farms), net income would be Rs. 2,217. Farmers would continue to grow

dryland crops only and no land would be developed for irrigation. When the credit constraint was removed, the use of credit would more than double, to Rs. 1,300, and net income would increase by 37 percent, to Rs. 3,046. Again, farmers would grow dryland crops only and no land would be developed. When both credit and land developed for irrigation were not constraints, net income increased to Rs. 4,773, which would be 2.2 times the net income when credit was limited and no irrigated crops grown. To produce this income, the use of credit would expand nearly four times; also 4.7 acres, or almost 40 percent of the total cultivable acres, would be developed for irrigation.

Changes in net income on Farm 4, representative of the larger farms, was proportionally less than for the smaller farms. Under credit restrictions of Rs. 4,000 and irrigable acres restricted to that presently developed, net income of Farm 4 would be Rs. 12,512 when paddy was permitted as a crop. To produce this income, only 7.2 irrigable acres of developed land would be used. This represents 18 percent of the total cultivable acres. Paddy would be grown to the extent permitted. When credit was not restricted and irrigable acres restricted to that presently developed, credit use would increase 90 percent, to Rs. 7,613, and net income would increase 27 percent, to Rs. 15,914. Fourteen and six-tenths irrigable acres, 37 percent of the total cultivable acres, would be used and the acreage authorized for paddy production would be utilized. When the constraints on credit and land developed for irrigation were both removed, there was essentially no change in credit use or in net income. Slightly more irrigable land would be used.

3. Tables 9 and 10, Aggregate Results of the Analysis

The aggregate results for the Fortieth Distributary were derived from the linear programming results on the representative farms by using the number of farms in each irrigation alternative as indicated in Table 3. The main purpose was to estimate the potential total value of crop production if the distributary were fully developed and land and water use regulations strictly enforced. Also, alternative cropping patterns consistent with the restrictions imposed can be evaluated. The aggregation was done for the situation where credit was unlimited and the irrigable acres restricted to that presently developed, as well as for the situation where both credit and the land developed for irrigation were not constraints.

Credit unlimited and irrigable acres restricted: With unlimited credit, but irrigable acres restricted to that presently developed,

the aggregate value of crop production for the distributary was Rs. 20.5 million under Regulations B and Rs. 19.1 million under Regulations A. Thus, the value of production was 7.7 percent greater under Regulations B than A. The cash inputs required under Regulations B were 6.7 percent greater, or Rs. 380 thousand. The value of production in excess of cash inputs operating under Regulations B was 8.1 percent, or about Rs. 1.1 million, greater than under Regulations A.

Table 9. Potential aggregate acreages, crop output, and cash needs under Regulations A and B, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India

	Acres grown	Value of cash inputs required	Gross value of production	Value of production in excess of cash inputs
		Rupees (000)		
Credit unlimited and irrigable acres restricted				
Regulations A:				
Paddy	318	111	364	253
Irrigated cotton	881	221	868	647
Irrigated kharif bajra	3,751	831	2,104	1,273
Irrigated rabi wheat	4,403	1,475	4,412	2,937
Irrigated kharif jowar	1,137	315	949	634
Dryland jowar	24,800	2,748	10,354	7,606
Total	35,290	5,701	19,051	13,350
Regulations B:				
Paddy	342	120	392	272
Irrigated kharif jowar	4,996	1,385	4,172	2,786
Irrigated rabi wheat	4,996	1,673	5,006	3,333
Dryland jowar	26,197	2,903	10,937	8,035
Total	36,531	6,081	20,507	14,426
Credit unlimited and irrigable acres unrestricted				
Regulations A:				
Paddy	677	237	775	538
Irrigated cotton	2,370	595	2,334	1,739
Irrigated kharif bajra	4,227	937	2,371	1,434
Irrigated rabi wheat	4,735	1,586	4,745	3,159
Irrigated kharif jowar	1,812	502	1,513	1,010
Dryland jowar	21,940	2,431	9,160	6,729
Total	35,751	6,288	20,898	14,610
Regulations B:				
Paddy	677	237	775	538
Irrigated kharif jowar	6,399	1,774	5,343	3,569
Irrigated rabi wheat	6,399	2,143	6,412	4,269
Dryland jowar	24,462	2,710	10,213	7,503
Total	37,937	6,863	22,743	15,878

Table 10. Land utilization under Regulations A and B, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India

Land utilization	Credit unlimited and irrigable acres restricted		Credit unlimited and irrigable acres unrestricted	
	Regulations A	Regulations B	Regulations A	Regulations B
	Acres			
Crops grown	35,290	36,531	35,761	37,937
Total cultivable land used	31,539	31,535	31,534	31,538
Double-cropped	3,751	4,996	4,227	6,399
Irrigated crops grown	10,490	10,334	13,821	13,475
Irrigable acres used	6,777	5,338	10,201	7,076

Slightly more land, 3.5 percent, would be cropped in the distributary operating under Regulations B than Regulations A. The acreage of developed land required if all farmers maximized their net incomes, however, would be 27.0 percent less under Regulations B. At the same time, double-cropped acreage operating under Regulations B would be one-third more than under Regulations A. The cultivable acres used would be the same under both sets of regulations.

Credit unlimited and irrigable acres unrestricted: The gross value of crop production for the distributary with unlimited credit and irrigable acres unrestricted was Rs. 22.7 million if Regulations B were followed and Rs. 20.9 million if Regulations A were put into effect. Thus, the value of production would be 8.8 percent, or Rs. 1.84 million, greater under Regulations B than A. The value of cash inputs required to enable farmers to maximize their net incomes would be more, 9.1 percent or Rs. 576 thousand, operating under Regulations B, but the value of production in excess of the cash inputs would be nearly Rs. 1.3 million, or 8.8 percent, more when operating under Regulations B than Regulations A.

Six percent, or 2,176, more acres would be cropped in the distributary operating under Regulations B than A. More developed land, however, would be used under Regulations A—10,201 acres compared to 7,076 under Regulations B, a difference of 3,125 acres, or 44 percent. Fifty-one percent, or 2,172, more acres of irrigable land would be double-cropped operating under Regulations B than Regulations A.

Overall comparisons: The gross value of crop production was increased under both sets of regulations when the constraint on irrigable acres was removed. The values were also greater under Regulations B than A. For example, under Regulations B, the

gross value of crop production for the distributary was Rs. 22.7 million with unlimited credit and irrigable acres unrestricted and Rs. 20.5 million with unlimited credit and irrigable acres restricted, a difference of Rs. 2.2 million, or 11 percent. When the same comparison was made operating under Regulations A, the difference was less, Rs. 1.8 million, or about 9.6 percent.

When the two credit and irrigable acreage situations were compared under both sets of regulations, the results in terms of the land utilization were quite different. Assuming Regulations A would be in effect, farmers operating with unlimited credit and no restrictions on irrigable land would 1) grow crops on 1.3 percent more acres; 2) grow 24.1 percent more acres of irrigated crops; 3) use 33.6 percent more acres of land developed for irrigation; and 4) double-crop 11.3 percent more acres than they would if operating under these regulations with unlimited credit and limited irrigable acres.

If we assume that Regulations B were in effect, farmers operating with unlimited credit and no restrictions on irrigable land would 1) grow crops on 3.8 percent more acres; 2) grow 23.3 percent more acres of irrigated crops; 3) use 24.6 percent more acres of land developed for irrigation; and 4) double-crop 21.9 percent more acres than farmers would if their land developed for irrigation were limited.

DISCUSSION

This study has examined the farm-and-area-level implications of two alternative sets of land and water use regulations that Tungabhadra irrigation project officials have considered for implementation.[19] Four representative farms were identified that are characteristic of the farms in the area studied. The most profitable crops that could be grown under varying restrictions of capital and land developed for irrigation were derived with linear programming and the results aggregated for all farms in the study area.

If the farmers' net incomes from crop production are to be

[19]Four additional sets of land and water use regulations were also examined: 1) where all available water is used for paddy during June through November and with no light irrigation allowed; 2) where the land is used for light irrigated crops only as outlined in Regulations A and no provision for the use of water on lands authorized for paddy; 3) where the land is used for light irrigated crops only as outlined in Regulations B and with no provision for the use of water on lands authorized for paddy; and 4) where water adequate for light irrigated crops is provided from January through April and in which paddy is allowed from June through November.

maximized under the constraints examined, TBP officials should implement Regulations B, make provisions for unlimited credit and land developed for irrigation, and permit irrigation for both the light irrigated crops and paddy according to the irrigable acres permitted.

Summarized data for all farms show that net income per farm would be more operating under Regulations B than A irrespective of the credit and irrigable land situations. Net income per farm operating under Regulations B would be about eight percent more than under Regulations A when both credit and land developed for irrigation were unlimited, and five percent more when credit was unlimited but irrigable acres restricted to those presently developed (Table 11). The credit used, man-hours of labor required, and the acres double-cropped per farm to obtain such income would also be greater under Regulations B. Acreage of land developed for irrigation per farm, however, would be less.

In implementing and enforcing the regulations adopted, TBP administration must consider many social and political factors. Adjustments must necessarily be made, and farmers must understand and be convinced that economic benefits for the area will be gained by enforcing regulations. Presently, many farmers view enforcement in terms of "giving up paddy" and not in terms of "equitable allocation of water." To implement the regulations, many farmers will receive less water than they are presently using (often illegally) and others who are receiving little or no water will be allocated more. The problem is to muster the farmers' support for enforcing the regulations. Local support is an absolute essential if the program is to succeed.[20]

The findings for these sets of regulations are not reported for the representative farms because the relative profitability of the different crops grown is reflected in the analysis for Regulations A and B. In the paddy-only situation, 1) above, paddy is the only irrigated crop permitted and thus the results were not very meaningful. The findings for 2) and 3) above were virtually the same as those under Regulations A and B and to report them would be redundant. The findings for 4) above are not presented because upon aggregating the data, the resulting values of crop production were not as favorable as the results from the analysis of the other regulations, except for the paddy-only situations which were the least favorable.

[20]Under the present poorly defined system of water allocation, the regulations are not clearly understood or strictly enforced. This has resulted in many political and social pressures; many arguments among farmers, TBP administrators, Public Works Department inspectors, and tax officials; occasional physical force; and sporadic violence between disgruntled farmers. Occasionally, the entire distributary has been "dammed up" to increase the flow of water to certain farmers and a considerable number of locks on shut off gates have been broken.

Table 11. Selected variables compared under Regulations A and B, three credit and land developed for irrigation situations, 1,443 farms, Fortieth Distributary, Tungabhadra Irrigation Project, Mysore State, India

Regulations	Net income level per farm, Rs.	Credit used per farm, Rs.	Annual man-days labor required per farm	Irrigable acres per farm	Acres double-cropped per farm	Gross value of production Fortieth Distributary, million Rs.
Regulations A:						
Cr. ltd. & irr. A res.	6,218	1,872	579	3.1	0	—
Cr. unltd. & irr. A res.	7,955	4,001	704	4.7	2.6	19.0
Cr. unltd. & irr. A unres.	8,509	4,418	767	7.0	3.5	20.9
Regulations B:						
Cr. ltd. & irr. A res.	6,279	1,890	590	2.9	.2	—
Cr. unltd. & irr. A res.	8,356	4,344	734	3.7	2.9	20.5
Cr. unltd. & irr. A unres.	9,166	4,924	803	4.9	4.4	22.7

Any system of regulations will be difficult to enforce. However, with the present high cost of water meters and irrigation equipment, the general lack of communication in the TBP, and the low level of literacy of the farm population, regulations as suggested are presently the most feasible way of controlling water and land use. The suggested regulations provide a simple system that can be implemented with minimum technical equipment or highly trained personnel. After experience is gained from operating under the regulations, there will be opportunities for changing to a more complex system, such as varying planting dates for the crops grown, introducing other crops, and selling water rights to increase water use efficiency. First, however, farmers must understand the basic regulations and reasons for complying with them. Government officials, in turn, must be aware of the extent to which farmers in various situations have financial incentive to comply with the regulations being enforced or proposed. Hopefully this study has provided information about such incentives.

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