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An economic analysis of crops and land use localizations in the Tungabhadra Irrigaiton Project of Mysore State, Inda

Parker Ditmore Cashdollar

To the Graduate Council:

I am submitting herewith a dissertation written by Parker Ditmore Cashdollar entitled "An economic analysis of crops and land use localizations in the Tungabhadra Irrigaiton Project of Mysore State, Inda." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

M. B. Badenhop, Major Professor

We have read this dissertation and recommend its acceptance:

D. W. Brown, L. H. Keller, K. E. Phillips

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(Original signatures are on file with official student records.)

November 4, 1971

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Major Professor

We have read this dissertation and recommend its acceptance:

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AN ECONOMIC ANALYSIS OF CROPS AND LAND USE LOCALIZATIONS IN THE TUNGABHADRA IRRIGATION PROJECT OF MYSORE STATE, INDIA

A Dissertation

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

Parker Ditmore Cashdollar

December 1971

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ABSTRACT

A system of improved land use localizations for controlling the use of irrigation water is proposed for the Tungabhadra Irrigation Project (TBP) in Mysore State, India. Land use localizations determine which crops, to what extent, and in what season they can be grown. Lands are localized for "light" irrigated crops or for "heavy" irrigated paddy. To insure high levels of total production from a limited water supply, the great majority of land was initially localized for "light" irrigated crops. Localization regulations, however, are not being strictly enforced. This has resulted in farmers' growing more paddy, which appears to be the "preferred" crop, than is authorized. The growing of unauthorized paddy has resulted in a disorderly distribution of water and in frequent shortages.

The general objective of this study is to construct an economic model for use in analyzing agricultural phenomena in the black soil area of the TBP. The Fortieth Distributary was selected as the unit of analysis and representative farms were constructed for this distributary based on primary resource data collected from a random sample of farmers. This study investigates the profitability of various dryland and irrigated crops grown on the representative farms assuming that localization regulations are strictly enforced.

Linear programming analysis is used to determine the most profitable crops grown on representative farms under two sets of localization regulations for the Fortieth Distributary. Also, three models

are considered in which various levels of operating credit and land developed for irrigation are assumed to be available.

An aggregate analysis is also made to determine the total input requirements and production that are likely on the distributary under six different sets of localization regulations. Each set of regulations differs with respect to amount of acres of paddy allowed, and/or the seasons in which various crops can be grown, and/or the exact dates when irrigation water becomes available and terminates. The same representative farms used in the crop analysis are used in the aggregate analysis. Aggregate results are determined under assumed conditions of unlimited operating credit and unlimited land developed for irrigation.

Results of the crop analysis show that paddy may not be a "preferred" crop on many farms when localization regulations are enforced. The results show that in situations of limited operating capital the dryland crops compete favorably with irrigated crops, primarily because of the higher returns per rupee invested in cash inputs on the dryland crops. If operating credit is actually as limited to farmers as it was assumed to be in the limited operating credit model then the higher returns per rupee invested for the dryland crops may explain why many farmers have not adopted irrigation. It was found that paddy competes favorably with the light irrigated crops where developed land and capital are plentiful. However, when developed land is limited it is generally more profitable to double crop with two light irrigated short duration crops than to grow one crop of longer duration paddy.

Results of the aggregate analysis show that there are significant differences in aggregate production from a given supply of water, depending on the set of localization regulations that is in force. In general, there is little justification for using water for paddy if total production is the major goal in the TBP. Also, it was found that a set of localization regulations that allows a broad range of possibilities for double cropping light irrigated crops will yield greater total production. It was found that summer irrigation of light irrigated crops results in considerably less production because of heavy water requirements during this season and, also, because some of the more profitable light irrigated crops cannot be grown during the summer.

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CHAPTER I

INTRODUCTION

I. GENERAL INFORMATION

Throughout the centuries the Tungabhadra Area of Mysore State and Andhra Pradesh (state) has been plagued with recurrent famines due to drought conditions. There are many deserted villages in the area whose people migrated to other areas in an attempt to escape starvation. The Tungabhara River which flows through the area was a wild river with frequent flooding during the monsoons. This precluded the utilization of its waters for irrigation on a large scale. The lack of technology for harnessing the river meant that these waters flowed on to the sea leaving the Tungabhadra Area to be one of the most sparsely settled, impoverished and unenlightened areas of South India.

Food shortages accompanied by a fast growing population made it imperative that India develop her river systems for irrigation. In 1953 upon completion of the Tungabhadra Dam, the Tungabhadra Irrigation Project (TBP) became a reality. The TBP consists of the dam and reservoir and three major irrigation canals leading from the reservoir. The canals and other water distribution facilities have been in various stages of development since 1953. Only one of these canals, the Left Bank Low Level Canal (LBLLC), is dealt with in this study. The other canals are the Right Bank Low Level Canal (RBLLC) and the Right Bank High Level Canal (RBHLC).[1]

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[1] If one were facing downstream, the right bank canals would be to the right side and the left bank canal to the left side.

The TBP is located in Northeastern Mysore State with portions of the distribution system extending into Andhra Pradesh. The TBP is designed to irrigate 1,272,404 acres when it is fully developed and is one of the largest irrigation projects in South India. The RBLLC is 217 miles long and serves both Mysore State and Andhra Pradesh. It is planned to irrigate 241,070 acres and the water distribution network for that portion in Mysore State is virtually complete. The RBHLC is designed for irrigation only during the season of high water levels in the reservoir. It is to be 122 miles long and will serve both Mysore State and Andhra Pradesh. The RBHLC is ultimately to irrigate 451,334 acres, but the distribution network is only 25 percent complete.[2] Although this study focuses on the problems of the LBLLC, the results should have some applicability to the Right Bank Canals. A map of the TBP is presented in Figure 1.

The LBLLC is 141 miles long and lies entirely in Raichur District of Mysore State. It is designed to irrigate 580,000 acres which makes it the largest of the three canals. The distribution network for the LBLLC is virtually complete.[3]

All water is distributed by gravity flow. Thus, all the distributaries which lead from the LBLLC flow in a southerly direction toward the Tungabhadra River.[4] The water distribution system consists of the

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

[3]Ibid., pp. 29-31.

[4]This paragraph and all following information, unless otherwise noted, are referring to the LBLLC. Much of the general information, however, is applicable also to the other canals.

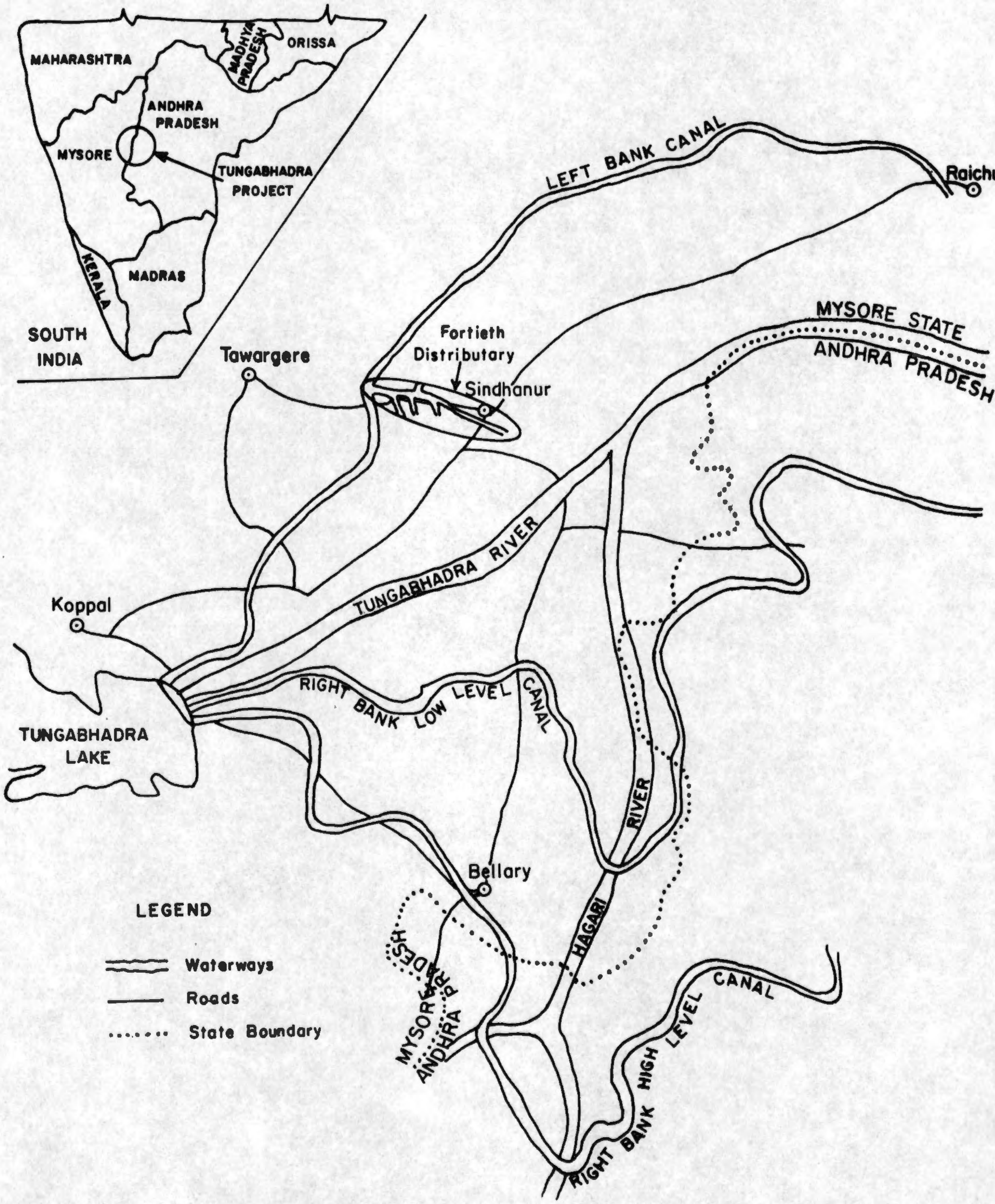

Figure 1. Map of the Tungabhadra Irrigation Project.

canal, distributaries which lead from the canal, subdistributaries, and field channels leading to the farmers' fields. The Public Works Department (PWD) constructed the distribution system and is responsible for its maintenance. The LBLLC is lined with concrete throughout its length to control erosion and reduce seepage losses. There are 106 distributaries leading from the LBLLC.[5]

The TBP was planned to be a "protective" irrigation system.[6] This means that it was designed to irrigate many acres of "light" irrigated crops such as wheat, cotton, and sorghum rather than to irrigate fewer acres of "heavy" irrigated crops of paddy and sugarcane. A common rule of thumb is that roughly three times as much water is required to grow an acre of paddy as for an acre of light irrigated crop. An alternative to the concept of protective irrigation would have been to construct shorter distribution systems, to serve fewer acres with water, but to allow farmers to grow heavy irrigated crops. However, this would not benefit nearly so many farmers nor would it get as much total production from the limited amount of water. There is little doubt that the TBP is now committed to supplying water in some measure throughout the vast water distribution network and it is upon

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[5]N. G. Joshi, "Constructional and Irrigation Aspects of TBP," Tungabhadra: A Citadel of Hope. Ed., Narasing Rao Madarkal (Bangalore: The Department of Information and Tourism, 1968), pp. 63-67.

[6]The term "protective" is a misnomer in the sense that it may falsely imply a less productive situation. Later analysis shows a "protective" system may also be the most productive system.

this commitment to "protective" irrigation that this study is based.[7]

Since paddy is generally the preferred crop of farmers in the TBP area, a system of land use localizations was created to force farmers to grow the light irrigated crops. All lands that were authorized for irrigation were localized into one of the two broad groups of light or heavy irrigation. In keeping with the concept of "protective" irrigation approximately 87 percent of the total localized lands were localized for light irrigation.[8] Lands localized for heavy irrigation are further categorized as sugarcane or paddy lands. Lands localized for light irrigation are further categorized as kharif, rabi, cotton, or garden lands.[9] Each subcategory is distinguished by the dates during which it receives its authorized flow of water. A more thorough explanation of land use localizations is taken up in Chapter II.

II. THE PROBLEM

For many years after water became available to farmers, the agricultural officials were very concerned because farmers were slow

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[7]Jayakumar Anagol, "A Strategy for Ayacut Development Under Major Irrigation Projects," Tungabhadra Project Achievements and Aspirations. Ed., Narasing Rao Madarkal (Bangalore: The Government Press, 1970), pp. 57-59.

[8]Ibid., p. 60.

[9]Kharif and rabi refer to the "fall" and "winter" cropping seasons, respectively, as well as to localizations. A thorough explanation of these terms is given on pages 12 and 13.

to develop[10] their lands for irrigation. However, it was soon realized that lands localized for heavy irrigation, that is, for paddy and sugarcane, were being developed faster than lands localized for light irrigation. Lands localized for heavy irrigation were being developed much slower than expected, but development of lands localized for light irrigation appeared to be almost nonexistent. However, closer inspection revealed that in red soil areas the lands localized for light irrigation were being developed as fast as lands localized for heavy irrigation. Since only about 20 percent of the LBLLC is in the red soil area, this posed a serious problem. In the black soil areas farmers believed that cultivation of light irrigated crops was not profitable and only lands localized for paddy and sugarcane were being developed.[11]

Farmers in the red soil areas reported that light irrigated groundnut was very comparable to paddy in profitability and they were willing to obey the localization regulations. In the black soil areas the farmers reported that peanut, hereafter called groundnut, did not grow well and that none of the light irrigated crops were at all comparable in profitability to paddy. Thus, farmers in the black soil areas were developing lands only for paddy cultivation. Since most farmers in the black soil areas were hesitant to violate localization regulations by growing paddy on lands localized for light irrigation, the development of lands progressed very slowly.[12]

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[10]Throughout the study "develop" means to develop for irrigation. Likewise, "developed land" means lands that have been developed for irrigation.

[11]Anagol, "A Strategy for Ayacut Development, p. 60.

[12]_Ibid_., pp. 59-60.

In an effort to increase land development, the TBP authorities agreed to allow all farmers to grow paddy on up to one-third of their lands that were localized for light irrigation. Although this surely encouraged farmers to develop lands, it also created new problems. Farmers came to realize that they could cultivate more than one-third of their lands in paddy and that the authorities were generally lax in enforcing this restriction. Water shortages began to occur as more lands were developed. Also, the growing of paddy on higher lands, originally intended for light irrigation, resulted in seepage and salinity problems on adjacent lands. In 1967 the concession of allowing paddy on one-third of the light localized lands was withdrawn.[13] However, by this time farmers were established in paddy cultivation and resistant to obeying the localization regulations which prescribed light irrigation on 87 percent of the lands.

The most immediate problem facing TBP authorities now appears to be how to encourage farmers to grow light irrigated crops instead of paddy. Coupled with this is the problem of moving toward strict enforcement of localization regulations. As all the distributaries become more fully developed, the violation of localization regulations results in a disorderly distribution of water. Many farmers entitled to water do not get their share if other farmers violate the regulations by growing paddy on light localized lands.

In addition to the major problems described above, there are the usual problems associated with the introduction of irrigation on a large

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[13] Ibid., pp. 60-61.

scale into a previously dryland area. There have been problems in providing draft power for land development, in providing government loans for development, and in providing the farm inputs needed for irrigated farming. There have been marketing problems caused by poor access roads and lack of local processing and storage facilities. There have been problems associated with the adoption of new varieties such as disease, insect damage, and a lack of knowledge on the part of cultivators.

III. OBJECTIVES

The general objective of the study is to construct an economic model for use in analyzing agricultural phenomena in the black soil area of the LBLLC. The Fortieth Distributary was selected as the unit of study upon which the study is based. The specific objectives are:

1. To determine by linear programming techniques the most profitable crops on representative farms in the Fortieth Distributary assuming localization regulations were strictly enforced.
2. To determine aggregate production and aggregate input requirements for the distributary under two sets of localization regulations that are similar to the proposed localization regulations.
3. To examine the likely results of changing the localization regulations: (a) to use all water for paddy cultivation, and (b) to use all water for light irrigation.

4. To examine the likely results of changing the localization regulations to allow paddy only to be grown during kharif season and only light irrigated crops to be grown during the summer season.

CHAPTER II

BACKGROUND INFORMATION

I. LOCALIZATIONS

One of the distinguishing characteristics of the TBP is the concept of land use localizations for controlling the use of water. Table II-1 shows the localizations for the LBLLC. Lands localized for heavy[1] irrigation are categorized as either sugarcane or paddy. Sugarcane localized lands are authorized to receive water at the rate of one cusec[2] per fifty acres for eleven months, from June through April. The LBLLC is closed during May for repairs. Paddy localized lands are authorized to receive water at the rate of one cusec per fifty acres for a six-month period from June through November.[3] A constant flow of one cusec per fifty acres is approximately one-half inch per acre per 24-hour day.

Lands localized for light irrigation are categorized as kharif, rabi, cotton, or garden. All light localized lands are authorized to receive water at the rate of one cusec per 160 acres. This is approximately one-sixth of an inch per acre per 24-hour day. Garden

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[1]In the TBP area the term "wet" irrigation is often used to mean the same as heavy irrigation. The terms "dry" irrigation and "dry-cum-wet" irrigation are often used to mean the same as light irrigation. Throughout this study only the terms heavy and light are used.

[2]A cusec is a constant flow of one cubic foot per second or 3600 cubic feet per hour. This is almost an acre inch per hour since an acre inch equals 3630 cubic feet.

[3]Interview with Narasing Rao Madarkal, Deputy Administrator TBP, At Sindhanur, February 8, 1971.

TABLE II-1

PROPOSED LAND USE LOCALIZATIONS ON THE LEFT BANK
LOW LEVEL CANAL

Localization	Acres
Heavy Irrigation	
Sugarcane	15,000
Paddy	60,000
Total Heavy Localization	75,000
Light Irrigation	
Kharif	200,000
Rabi	200,000
Cotton	75,000
Garden	30,000
Total Light Localization	505,000
Total Localization	580,000

Source: C. M. Revanna, "Development of TBP Ayacut in Raichur and Bellary Districts," Tungabhadra: A Citadel of Hope, ed. Narasing Rao Madarkal (Bangalore: The Department of Information and Tourism, 1968), pp. 30-31.

localized lands are authorized to receive water from June through April. Kharif lands are authorized to receive water for four months, generally from June through September. Rabi lands are authorized to receive water for four months, generally from the first of October through January. Cotton lands are authorized to receive water for six months, generally from the first of August through January.[4]

The terms, "kharif", "rabi", and "cotton" can be very confusing and deserve further explanation before proceeding. When referring to land localizations kharif means lands localized for light irrigation during the season from June through September. This localization was named kharif because it roughly corresponds to the "fall" cropping season, referred to as kharif season throughout India. Paddy, which is grown under paddy localization from June through November, is called kharif paddy because of the season in which it is grown. Generally, any crop planted in June or July that has a duration of four to six months is called a kharif crop whether or not it was grown on kharif localized land.

Rabi localized lands were so named because the period in which they receive water roughly corresponds to the rabi or "winter" crop season. When talking about seasons there is some overlapping of kharif and rabi seasons because often rabi season crops are planted before kharif season crops are harvested. When talking about kharif and rabi

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[4] Interview with Narasing Rao Madarkal, Deputy Administrator TBP, at Sindhanur, February 8, 1971.

localizations, however, there is no overlapping because the *kharif* irrigation ends before *rabi* irrigation starts.

The cotton localization, like the paddy localization, refers to a localization and not to a season. The cotton localization was created because the cotton crop has a six month duration and, if grown on *rabi* localized lands, does not receive water during August and September. Since cotton localized lands receive water for six months the four month duration *rabi* season crops may be grown on cotton localized lands. But cotton which requires six months of irrigation cannot be grown on *rabi* localized lands which receive only four months of water. The crop, cotton, is referred to as a *rabi* crop because its growing season is more nearly like the growing season of *rabi* crops than of *kharif* crops. Sometimes cotton is called a "*kharif-rabi*" crop.

Since water meters were impractical to install in the TBP the system of land localizations was created to control the use of water. As pointed out in Chapter I, and as will be discussed further in later chapters, there have been many problems associated with land localization.

The LBLLC is composed of distributaries which essentially are smaller canals leading from the main canal to the irrigated lands. There are 106 distributaries on the LBLLC. Each of the 580,000 localized acres is served by one of these distributaries. Thus all localized lands must receive water from a distributary rather than directly from the main canal.

The Fortieth Distributary was selected as the unit for analysis in this study. The land use localizations as proposed for the Fortieth

Distributary are presented in Table II-2. All sugarcane localizations were assigned to distributaries that are reasonably close to the dam and the sugar factory which is near the dam. Since the Fortieth Distributary takes off from the main canal at the 52 mile point from the dam it received no sugarcane localization.

On the Fortieth Distributary, as in all distributaries, the paddy lands are localized in blocks. These paddy blocks contain from 100 to 600 acres of contiguous lands that are in basins or lower elevations within the distributary. Paddy is localized in blocks at the lower elevations because the standing water in paddy fields causes adjacent lands to become waterlogged and salt damaged. Thus many widely scattered small paddy fields at higher elevations result in much land "spoilage" of this nature. Farmers adjacent to paddy fields that are not localized for paddy are "forced" to take up paddy cultivation because their lands are "spoiled" for other crops. Farmers frequently offer this as an excuse for growing paddy illegally.

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

The necessity of generally following ridges with the irrigation ditches means that the lands localized on a distributary create an irregular pattern. That is, there are large areas of nonlocalized lands interspersed with the localized lands. This means that most farmers are likely to own some nonirrigable lands as well as localized lands.

TABLE II-2

PROPOSED LAND USE LOCALIZATIONS ON THE FORTIETH DISTRIBUTARY OF THE LBLLC

Localization	Acres
Heavy Irrigation	
Paddy	677
Light Irrigation	
Kharif	5,228
Rabi	5,331
Cotton	2,590
Garden	457
Total Light Localization	13,606
Total Localization	14,283

Source: "Distributarywise Localization Statement for Distributaries 36 to 56," Executive Engineer PWD, Sindhanur, an unpublished bulletin, 1969, p. 4.

In this study the Fortieth Distributary is defined to include all lands, both localized and not localized, that are owned by farmers who own some localized land on the Fortieth Distributary. Using this definition it was found from the survey[5] data that 31,540 crop acres, including the 14,283 localized acres, are actually in the Fortieth Distributary.

II. CLIMATE

The TBP area is characterized by low average rainfall and high average temperatures. Average monthly rainfall data for the TBP area are presented in Table II-3. The TBP area receives rainfall from both the southwest and northeast monsoons but does not receive the full effect of either. The southwest monsoon begins in May and ends in September while the northeast monsoon begins in October and ends in December. Prior to receiving irrigation water, farmers waited until the first good rains to plant their crops. If the early monsoon was good then they tried to plant in June or July. If it was not good then they waited until the generally heavier northeast monsoon came and planted in September or October.

April and May are the hottest months with mean maximum temperatures averaging 100.6 degrees Fahrenheit and a mean daily temperature of 89.2 degrees. December is the coolest month with a mean daily

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[5]"The survey" refers to data collected by the author and N. T. Paramasiviah by a random sample survey of farmers on the Fortieth Distributary during January and February of 1971. Throughout the thesis any reference to the "survey" means the Cashdollar-Paramasiviah survey unless specifically stated otherwise.

TABLE II-3

AVERAGE MONTHLY RAINFALL AND MONTHLY PERCENTAGE OF ANNUAL RAINFALL IN THE TBP AREA AT BELLARY

Month	Rainfall in Inches	Monthly Percentage of Total Rainfall
January	0.08	0.4
February	0.07	0.3
March	0.16	0.8
April	0.93	4.5
May	2.26	11.0
June	1.85	9.1
July	1.93	9.4
August	3.03	14.8
September	4.40	21.5
October	4.10	20.0
November	1.30	6.4
December	.36	1.8
Total	20.47	100.0

Source: *Project Work Plan--Regional Pilot Project for Soil and Water Management, Bellary, Mysore State* (Bangalore: Government of India, 1969), pp. 9-19.

temperature of 73.7 degrees Fahrenheit.[6] The generally warm temperatures throughout the year provide for a twelve month growing season. The shortage of rainfall, however, precludes dryland farming except during the rainy season.

III. SOILS

Two soil groups are found on the LBLLC, the red loam soils and the black clay soils. The black clay soils comprise 80 percent of the localized area, and it is in the black soil area where most of the problems exist. The red soils are loamy in texture and contain 10 to 20 percent clay.[7] They are well drained and easy to cultivate. Most crops grow well on red soils including groundnut which is very profitable in the TBP. The chief criticism of red soils is that when used for paddy deep percolation losses are high relative to the black soils.[8]

The black soils, also called black cotton soils, contain 40 to 50 percent clay and have a high moisture holding capacity. They have pH values of seven to nine and are well supplied with calcium, magnesium and potassium. Their content of organic matter, nitrogen and phosphorus

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[6] Project Work Plan - Regional Pilot Project for Soil and Water Management, Bellary, Mysore State (Bangalore: Government of India, 1969), p. 8.

[7] B. V. Vankata Rao, Soil Resources of Mysore (Bangalore: University of Agricultural Sciences, 1968), p. 3.

[8] Gerald Kester and A. S. Puttu Ram, "A Comparative Study of the Water Used in Growing Paddy on Contrasting Soils in the Tungabhadra Command Area," Regional Pilot Project for Soil and Water Management, Bellary, an unpublished paper, 1970, p. 4.

is low. These soils shrink and swell and develop large cracks during dry periods.[9] Black soils are heavy and more difficult to cultivate than red soils. Their chief advantages are their water retentive capacity and their structure which holds deep percolation to a minimum in paddy cultivation. Their main limitations are their tendency toward alkalinity and salinity under heavy irrigation and their high bulk density which is not conducive to growing groundnut.[10]

This study is limited to the black soil area which includes the Fortieth Distributary. No detailed soil survey of the TBP area has been made.[11] All soils on the Fortieth Distributary are assumed to be black soils of comparable quality.

Experience in irrigating the black soils at the Siruguppa Agricultural Research Station (A.R.S.) shows that there is practically no upward movement of salts under light or heavy irrigation under well drained conditions. However, at the Gangavati A.R.S., where drainage has been poor, black soils have become salt affected.[12] Considerable areas have become salt affected at the Gangavati A.R.S. and are unfit for cultivation. Researchers are presently experimenting with tile

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[9]Rao, Soil Resources of Mysore, p. 5.

[10]Interview with H. P. Achar, Agronomist at the Siruguppa A.R.S., at Siruguppa, February 23, 1971.

[11]Interview with R. S. Murthy, Soil Correlator, at Bangalore, November 12, 1970.

[12]S. V. Patil and B. V. Venkata Rao, Effects of Irrigation on Black Soils in the Tungabhadra Project Area in Mysore State (Bangalore: University of Agricultural Sciences, 1965), pp. 4-5.

drains and open ditches in an effort to reclaim the salt affected lands.[13] The exact magnitude of the problem of salt affected land throughout the TBP area is difficult to estimate because the problem frequently occurs in scattered small patches adjacent to paddy lands. Officials are becoming increasingly concerned about the problem and plans have been made for a drainage system throughout the TBP. The problems of salinity and the rising water table are not dealt with in this study.

IV. LAND DEVELOPMENT

The PWD has constructed field channels to the farmers' fields, but it is the farmers' responsibility to develop his lands for irrigation. This involves leveling the lands, constructing dikes (bunds) around the fields, and constructing small channels for transporting water between fields. Lands can be developed with bullock power, tractor power, or with manpower using headbaskets to move the soil.

The two basic methods of developing land are for border strip irrigation and for level basin irrigation. The level basin method must be used if paddy is to be grown. It also can be used for light irrigated crops even though the border strip method is generally recommended. The level basin method involves leveling of the land, constructing bunds around the field, and constructing water inlets at the upper side of the

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[13]Interview and field trip with Messrs. Jayaramiah, Parmasappa, and Khan, personnel at Gangavati A.R.S., at Gangavati, February 9, 1971.

field.[14] The common practice in the TBP is to have several fields of this nature at successive lower elevations. This way water must move through the higher elevation fields to get to the lower fields. It is recommended that lateral ditches be constructed to avoid having water flow through one field to get to another.[15]

The advantages of the level basin are that the final leveling can be done by flooding the field, it is relatively easy to design, and even if crudely constructed, it is reasonably satisfactory. It makes maximum use of rainfall and no water need be lost through runoff. Level basin fields are easy to irrigate even by unskilled labor.[16]

The border strip method cannot be used for paddy but is the recommended method for light irrigation. The fields are not leveled but are left with a gentle slope of .05 to 0.5 percent down the length of the field. Just enough slope is kept in the strips to assure an even distribution of water. Some leveling is generally needed, however, and the strips or rows must be properly constructed to work effectively. The main advantage of this method is that the longer rows make tillage operations easier than in level basins. The limitations are that unless

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[14] Handbook on Irrigation Water Management (New Delhi: Department of Agriculture, 1970), pp. 14-19.

[15] Interview with E. W. Shaw, Team Leader of the U.S.A.I.D. Soil and Water Management Team with the Regional Pilot Project at Bellary, February 23, 1971.

[16] Handbook on Irrigation Water Management, p. 19.

fields are properly constructed, it is difficult to get an even application of water and irrigation requires a more skillful operator.[17]

The survey shows that of the total land developed for irrigation on the Fortieth Distributary, only 13 percent is developed by the border strip method. In traveling in the black soil area one must make a conscious effort to locate fields irrigated by border strip. In the red soil area, however, general observation indicates that border stripping is more common than level basin irrigation. Generally, these border stripped fields in the red soils are planted to groundnut. Although level basins account for most of the developed land on the Fortieth Distributary, they are frequently used for light irrigation rather than paddy.

Throughout the TBP area lands are naturally level with slopes rarely exceeding three percent. Developing lands, however, is still a very laborious process. Government sponsored tractor societies have been created to supply power for land development. However, the results of the survey show that on the Fortieth Distributary bullock power is still the primary means of land development.

V. INFRASTRUCTURAL SERVICES

Sindhanur, the largest town and only trade center in Sindhanur _Taluk_, a political subdivision similar to a county in the United States, has an estimated population of 10,000. It is on the main highway between

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[17] _Ibid_., pp. 14-16.

the cities of Bellary and Raichur and is about 80 miles from each. Sindhanur is the supply point for all the villages on the Fortieth Distributary which is entirely in Sindhanur Taluk. All government agencies serving Sindhanur Taluk have their field level offices located in Sindhanur. It is also the center for traders, moneylenders and merchants.

Markets

Sindhanur has no regulated (government supervised) market for farm products. Regulated markets are at Raichur, Bellary and Gangavati which is about 40 miles by road from Sindhanur. However, there is a Taluk Agricultural Produce Cooperative and Marketing Society (TAPCMS) at Sindhanur which supplies inputs to farmers on a cash basis and buys farm products. All produce bought by the TAPCMS is transported to the Raichur Regulated Market and resold. The farmer receives 60 percent of the value of his produce when he delivers it to the TAPCMS and the balance after it is sold at Raichur.[18] Generally the TAPCMS has a good supply of seeds, fertilizers and chemicals.

It was estimated that 75 percent of the farmers in Sindhanur do not trade at the TAPCMS because it sells supplies only on a cash basis and also is distant from many villages. There are many traders and merchants in Sindhanur who sell supplies on a credit basis and thus the indebted farmers also sell their produce to these merchants.[19]

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[18] Interview with S. Babu, Assistant Manager of TAPCMS at Sindhanur, February 22, 1971.

[19] Interview with S. Babu, Assistant Manager of TAPCMS at Sindhanur, February 22, 1971.

Credit

Agricultural credit sources in Sindhanur are the State Bank of Hyderabad, the Syndicate Bank, the Sindhanur Taluk Cooperative Society, and the noninstitutional sources of moneylenders, traders and merchants. Also, the Primary Land Development Cooperative Bank (PLDB) of Sindhanur supplies longer term credit for land development.

Both of the commercial banks made loans to farmers only for crop expenses. Each loan is under a "scheme" that is very restrictive as to who qualifies for the loans, the purpose, and the amount. The Syndicate Bank has been making farm loans in Sindhanur only since 1969. It has about 450 loans outstanding. These loans are made to selected credit-worthy farmers at 10 percent interest. The borrowers must be landowners and give a crop lien.[20] The State Bank of Hyderabad started making farm loans in Sindhanur in 1968. Loans are made only to owners of irrigated land whose farms are accessible all year from Sindhanur. Slightly over 300 loans are outstanding.[21] Since farm loans are generally hard to collect, the commercial banks are forced to be very selective of their borrowers. Moneylenders were reported to dominate the farm credit market with interest rates of up to 100 percent being common.[22]

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[20] Interview with A. Vamanaacharya, Manager of the Syndicate Bank, at Sindhanur, February 8, 1971.

[21] Interview with Laxami Rao, Manager of the State Bank of Hyderabad, at Sindhanur, February 8, 1971.

[22] Interviews with Laxami Rao and A. Vamanaacharya, at Sindhanur, February 8, 1971.

The Sindhanur Taluk Cooperative Society loans money to village societies which in turn make loans to farmers. Most farm loans are short term, that is, for one crop season. Loans are made only to land-owners. It was reported that several of the village societies on the Fortieth Distributary are in default on their loans from the Sindhanur Taluk Cooperative Society and are now inactive.[23] Generally, cooperative loans are made at 8 to 10 percent interest.

Attempts to discuss lending policies of moneylenders with money-lenders were generally unsuccessful. However, discussions with farmers and others indicate that the minimum rate at which moneylenders make loans is 2 percent per month and ranges up to 10 percent per month. Farmers in the survey reported that the rate paid to moneylenders is determined by the confidence the moneylender has in the borrower, the security that is offered, and the borrower's desperation for the loan.

The Primary Land Development Cooperative Bank (PLDB) makes loans for land development under the Agricultural Refinance Corporation of India Scheme (ARC). It has other schemes for purchasing pumpsets and tractors. The ARC loans are made at 8.5 percent interest and are amortized over 10 years. A mortgage is taken on the farmer's land. All development work must be inspected and approved by the Agricultural Development Office. Loans of Rs. 210[24] per acre are made for developing

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[23]Interview with S. V. Patil, Loan Superintendent of District Central Cooperative Bank of Raichur, at Sindhanur, February 8, 1971.

[24]Rupees is commonly abbreviated Rs. and precedes the quantity to which it refers. One dollar is equal to about Rs. 7.5.

land with less than 1 percent slope. Rs. 310 are loaned per acre for lands with more than 1 percent slope. However, an additional Rs. 48 per acre can be obtained if additional work is needed.[25] The PLDB has 3,500 loans outstanding under the ARC scheme for a total of Rs. 9,200,000. Farmers have generally been slow to repay their loans and 65 percent of the loans are behind on payments.[26]

A summary of the indebtedness of the 116 farmers selected in the random sample survey of farmers on the Fortieth Distributary is presented in Table II-4. Taccavi loans are loans that were made directly to farmers by the government. This program was discontinued several years ago but many farmers have still not repaid the loans.[27] Taccavi loans were not actively serviced for collection and collections were poor. Table II-4 shows that 58.2 percent of outstanding indebtedness on the Fortieth Distributary was supplied by moneylenders.

Since PLDB loans are for land development and taccavi loans are no longer being made, the only sources of operating credit shown in Table II-4 are cooperatives and moneylenders. If we assume the cooperatives and moneylenders are the only sources of operating credit, then moneylenders are supplying 87.2 percent of the operating credit. Of course, much of the money advanced by moneylenders may be going for land

[25] Interview with S. Mohanrao, Field Supervisor PLDB, at Sindhanur, February 25, 1971.

[26] Interview with C. Agha, Chief Accountant PLDB, at Sindhanur, February 8, 1971.

[27] Farmers and officials reported that taccavi loans are no longer being made in the TBP area, but the loan program is active in some parts of India.

TABLE II-4

SOURCE, AMOUNT OUTSTANDING, AND PERCENTAGE OF TOTAL INDEBTEDNESS OF A RANDOM SAMPLE OF 116 FARMERS ON THE FORTIETH DISTRIBUTARY

Source	Amount Outstanding (in rupees)	Percentage of Total
PSDB	45,490	27.2
Cooperatives	14,150	8.4
Taccavi	10,370	6.2
Commercial Banks	0	0
Moneylenders	97,200	58.2
	167,210	100.0

development and consumer goods, as well as for operating expenses. The results of the survey indicate that the commercial banks have not contributed to the credit supply on the Fortieth Distributory.

Roads

The roads leading between the main towns in the TBP are all weather asphalt roads. However, unless a village is very near one of these asphalt roads its farmers have difficulty getting produce to market during rainy seasons. Service roads to the outlying villages in the Fortieth Distributary are generally unimproved. These roads are simply rights-of-way that may be impassable during wet seasons. The PWD is now constructing roads to villages off the main roads and has plans for constructing roads throughout the TBP. Bridges over the Fortieth Distributary to connect the villages with the main road have already been constructed.

CHAPTER III

THE GENERAL MODEL

This chapter describes the construction of the general model. The general model is the basic linear programming model that is used throughout the analysis. Although several specific models are used, they are all simply variations of the general model. The differences between the specific models consist of changes in the amount of resources available, changes in localization regulations, and changes in the cropping activities that are permitted. The differences between the specific models are presented as the specific models are outlined in later chapters.

I. THE UNITS OF ANALYSIS

This study seeks to determine the most profitable crops on representative farms in the black soil area. In this sense it is a microeconomic study and representative farms are the basic units of analysis. However, the study also seeks to show the aggregate results within the Fortieth Distributary under different localization situations and in this sense is a macroeconomic study. Thus, the two units of analysis are the representative farms and the Fortieth Distributary.

The Fortieth Distributary

The Fortieth Distributary was selected for study for several reasons. It is in the heart of the black soil area which is where most of the important problems on the LBLLC are found. It consists entirely of the black soils characteristic of the area. The Fortieth Distributary lies entirely in the Sindhanur Taluk which means governmental administration and services should be relatively uniform throughout the distributary. With 14,283 acres localized it is of "representative" size among the above average size distributaries on the LBLLC. The average size distributary on the LBLLC has 5,471 localized acres. However, there are many small distributaries of less than 1,000 acres. There are also many distributaries ranging in size from 5,000 to 45,000 localized acres and the Fortieth Distributary is representative of this group.[1]

The Fortieth Distributary is typical of most distributaries because it contains several villages with some near the main road and some not. It was recommended by Department of Agriculture officials in Sindhanur as a distributary in which most problems of the black soil areas were being encountered. It is also a distributary that has received no "special" attention by development agencies nor has it received less than normal attention.[2] It is a distributary where agricultural officials were known to be cooperative and villagers were generally receptive to strangers collecting data.[3]

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[1]Narasing Rao Madarkal, "Statement Showing Distributarywise Localized Area for Distributaries on the Left Bank Canal," Deputy Administrator, TBP, Sindhanur, an unpublished bulletin, 1969, p. 1.

[2]Interview with A. B. Bellary, Assistant Development Officer, at Sindhanur, December 11, 1970.

[3]Interviews with Donald C. Taylor and S. Bisaliah, Professors of Agricultural Economics at MUAS, at Bangalore, December 1970.

The Representative Farms

The production of crops in a given area is the sum of the production of all the farms in the area. Since it is impractical to prepare production budgets for every farm within an area as large as the Fortieth Distributary, another approach is used. In this study representative farms are used for the microeconomic analysis of profitable crops and also for aggregation to determine total distributary production in the macroeconomic analysis. The concept of aggregating over representative farms to determine total production is a commonly used technique. However, the representative farm approach has problems and limitations as pointed out by Barker and Stanton,[4] Sharples,[5] and Miller.[6] Linear programming, a proved technique in farm management, is used for optimizing net incomes on the representative farms.

II. DATA SOURCES

Resource Restriction Data

Data used in constructing the representative farms, their resource restrictions, and distributary restrictions were taken from three main

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[4]Randolph Barker and Bernard F. Stanton, "Estimation and Aggregation of Firm Supply Functions," Journal of Farm Economics, Vol. 47, No. 3, August 1965, pp. 701-712.

[5]Jerry Sharples, "The Representative Farm Approach to Estimation of Supply Response," American Journal of Agricultural Economics, Vol. 51, No. 2, May 1969, pp. 353-360.

[6]Thomas Miller, "Aggregation Error in Representative Farm Linear Programming Estimates," Ph.D. Dissertation, Iowa State University, 1967, pp. 11-26 and 158-165.

sources: (1) data collected in the Cashdollar-Paramasiviah survey on the Fortieth Distributary, (2) publications and records of government and private agencies in the TBP area, and (3) interviews with knowledgeable officials and farmers in the vicinity of the Fortieth Distributary.

Since secondary data regarding on-farm resources were very limited, a random sample survey of farmers owning localized land on the Fortieth Distributary was conducted. This survey, the Cashdollar-Paramasiviah survey, consisted of interviewing 116 farmers regarding their resources.[7] A copy of the questionnaire that was completed for each farmer is reproduced in Appendix A. This random sample of 116 farmers represented 8.038 percent of the 1,443 farmers who owned some land localized for irrigation on the Fortieth Distributary and constituted the population.

Secondary data were relied upon primarily for determining total water availability in the distributary and for supplementing data from the survey. Published data regarding the Fortieth Distributary were in limited supply. However, PWD officials in Sindhanur were cooperative in making distributary records, maps, and routine statements available for review. Considerable information regarding resource restrictions was obtained by talking with appropriate officials and village leaders.

Crop Data

Input-output and cost-return data for the crop activities in the model were taken from several sources. The major sources were: (1) the

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[7]Actually attempts were made to interview 119 farmers selected in the sample. Three of these were either unavailable for interview or were nonfarming widows who rented out their very small acreages.

Bisaliah-Taylor study,[8] (2) the Farm Planning Manual,[9] (3) the Jones-Hayavadanachar study,[10] (4) the Package of Practices,[11] (5) miscellaneous publications of the Mysore Department of Agriculture, and (6) miscellaneous research publications of the Mysore University of Agricultural Sciences (MUAS). In addition to these sources of printed data, numerous interviews were held with researchers in the TBP area. Researchers at the MUAS research stations in Siruguppa, Gangavati, Hagari, and Raichur were interviewed and valuable information was obtained that had special applicability to the TBP area. The actual input-output data used represent a synthesis of all the sources of data.

Prices of most inputs used in crop production were February 1971 prices at the Taluk Agricultural Produce Cooperative and Marketing Society at Sindhanur. Other input prices were taken from the survey. The output or product prices used were average prices for 1970 at the Raichur Regulated Market. Prices for fodder and farmyard manure (FYM) were taken from the survey or the Bisaliah-Taylor study.

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[8] S. Bisaliah and Donald C. Taylor, "An Economic Analysis of Major Irrigated Crops in the Tungabhadra Irrigation Project," University of Agricultural Sciences, Bangalore, an unpublished bulletin, 1971.

[9] C. Nanja Reddy, K. C. Hiremath, and Estel H. Hudson, "Farm Planning Manual," University of Agricultural Sciences, Bangalore, an unpublished bulletin, 1970.

[10] Don Jones and B. R. Hayavadanachar, "Enterprise Budgets on Crops Grown on Black Soils under the LBLLC and LBHLC and on Red Soils under the LBLLC," Regional Pilot Project for Soil and Water Management, Bellary, an unpublished paper, 1969.

[11] Package of Practices for High Yields (Bangalore: University of Agricultural Sciences and Department of Agriculture, 1970).

III. THE REPRESENTATIVE FARMS AND RESOURCE RESTRICTIONS

There are several important factors that distinguish one farm from another and ultimately determine the farm's production. Total cultivable acres, developed acres, family labor supply, owned bullock power, cash on hand, and credit availability are the major factors that are considered in constructing the representative farms.

Total Acres and Developed Acres

An analysis of the factors listed above for the 116 farms in the sample revealed that number of acres developed for irrigation was the key factor for stratifying the farms. Four strata were delineated based on developed acres and each farm was placed in the appropriate stratum.

The four strata are: (1) Stratum I, farms with no developed land; (2) Stratum II, farms with some but not more than three acres of developed land; (3) Stratum III, farms with more than three but not more than seven developed acres; and (4) Stratum IV, farms with more than seven developed acres. After placing each farm in the appropriate stratum, the characteristics of the representative farms were determined by averaging for each stratum. That is, arithmetic means were calculated within each stratum for every quantifiable characteristic believed to be important to this study. The results of these calculations, the arithmetic means, describe an "average" farm for each stratum. The "average" farm for each stratum is defined to be a representative farm for this study. The characteristics of the four representative farms, hereafter referred to as Farm 1, Farm 2, Farm 3, and Farm 4,[12] are given in Table III-1.

In the survey most farmers reported considerable "wasteland" with their total acres. Wastelands are lands that are weed infested, salt affected, in overflow areas, or uncultivable because of rock outcroppings. Approximately 10 percent of total lands were reported as wastelands and were not included in calculating the total cultivable acres as shown in Table III-1. Throughout the study total acres is used to mean the same as total cultivable acres.

Farmer 1 is representative of 16 percent of the farmers on the Fortieth Distributary, or about 224 farmers. However, farmers like Farmer 1, that is, in Stratum I, own only 9 percent of the land and own none of the developed land. For reasons which can only be hypothesized, these farmers have developed no land and have not taken advantage of irrigation.

Farmer 2 represents 41 percent of the farmers, who own 27 percent of the land, and 17 percent of the developed land. Farmer 3 represents 22 percent of the farmers, who own 27 percent of the land, and 22 percent of the developed land. Farmer 4 represents 21 percent of the farmers, who own 37 percent of the land and 61 percent of the developed land.

Labor Supply

In the survey, farmers reported the number of men, women and children in the family labor force and how many hours they were available

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[12] These four representative farms become eight representative farms later in the study when localizations are assigned. Reference may also be made to Farmer 1, Farmer 2, Farmer 3, and Farmer 4 to denote the manager of the respective farm.

TABLE III-1

CHARACTERISTICS OF THE FOUR REPRESENTATIVE FARMS DERIVED FROM SURVEY DATA

Item	Unit	Farm 1	Farm 2	Farm 3	Farm 4
Total Cultivable Land	Acres	11.849	14.244	26.723	39.262
Developed Land	Acres	0.000	1.983	4.711	14.540
Men in Family Labor Force	Men	1.444	1.660	1.538	2.041
Women in Family Labor Force	Women	1.000	1.700	1.358	1.250
Owned Bullock Power	Bullock Pairs	.833	.916	1.115	1.750
Cash on Hand	Rupees	12.500	36.500	223.000	1383.3
Nonreal Estate Assets	Rupees	805.8	1366.1	1821.9	4831.0
Debts	Rupees	631.0	1038.0	2330.0	1914.0

per month. Very few farmers reported children in the labor force other than for tending bullocks, watching crops, and other miscellaneous tasks. Since so very few children were reported they are not considered in the labor force.[13]

The farmers reported that the men and women in the family labor force were available for work for at least eight hours per day every day of the year. The farmers reported that during peak labor periods the family worked very long days, generally more than eight hours.

Based on these results, it was assumed that all men and women reported in the labor force would be available for 250 hours per month for the full year. The hourly labor requirements for producing the various crops are in terms of man-hours per month. To determine the total man-hours available per month, the men and women available, as reported in Table III-1 were converted to man-hours available. Man-hours supplied by men per month were obtained simply by multiplying the men available by 250 hours. Man-hours supplied by women per month were determined by multiplying the women available by 250 and then reducing this amount by multiplying by the factor .80. This factor, .80, was used to convert woman-hours to man-hours on the assumption that wage rates reflect productivity. The wage rate for women throughout the survey was most commonly reported to be 80 percent of the wage rate

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[13]Although child labor is not included in labor availability, certain miscellaneous activities such as tending bullocks, watching crops, carrying water, and other tasks incidental to production are likewise not considered in the labor requirements of the crops. It is assumed that children will perform many of these tasks.

for men. Using this technique the monthly man-hours supplied by men and women were determined and added together to get the total family labor supply in man-hours per month. The resulting family labor constraints are 561, 755, 655, and 760 man-hours per month for Farms 1, 2, 3, and 4, respectively. These family labor constraints are used in all the models.

In addition to family labor, the farmers reported that considerable hired labor was available. Very few farmers reported difficulty in obtaining hired labor during the busy seasons. Also farmers, especially those in Stratum IV, reported many permanent servants.[14] Farmers in Stratum IV had an average of two male permanent servants. Farmers in Stratum III had an average of four-tenths of a permanent servant. Very few permanent servants were hired by farms in Strata I and II. Village leaders in the larger villages reported that 10 to 15 percent of the village population were landless laborers who are also in the hired labor force. Most farmers in Strata I and II reported earning some income by working on other farms as hired laborers. Also, there is some migrant labor in the area and a refugee camp for Indian Repatriates from Burma and Ceylon. These refugess often work for daily wages on the Fortieth Distributary. Based on these factors and the general belief that surplus labor does exist in India, no restriction was placed on hired labor availability in the models.

Wage rates paid for hired men were determined from the survey to range from Rs. 2.5 to Rs. 3.0 for an eight hour day during the busy

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[14]A permanent servant is a person who "hires out" to a farmer generally for a year or more for a determined salary. Often he may share in the crop and may be furnished subsistent needs in addition to a salary.

season. Based on these results, the wage rate for this study was assumed to be Rs. 2.8 per day or Rs. 0.35 per man-hour. An activity of hiring labor is included in all models at this wage rate.

Farmers were asked in the survey if there were any farming operations that men or women did not perform. The answer was generally emphatic that women never performed operations that required them to drive bullocks. However, women were reported to perform all other operations that men perform. It was reported that men generally did not transplant paddy, weed paddy, or pick cotton. However, most men said that although women generally performed these jobs, men would do them if there were a shortage of woman labor. In every representative farm situation there are more male supplied man-hours available than there are bullock pair hours available. Therefore, there should never be a shortage of men to drive bullocks. Therefore, it is assumed that perfect substitutability of male and female labor exists at the rate of one woman-hour equals .80 man-hours. Using this assumption, all woman-hours were converted to man-hours and only man-hours were included in the models.

Bullock Power

Bullock power is considered to be the only source of draft power in this study. Although a few tractors are seen in the TBP area, they are generally used for land development on a contract basis. Occasionally tractors are seen ploughing land and puddling paddy fields. However, bullock power is still overwhelmingly the main source of power. Bullock pair hours were used in calculating the draft requirement and the bullock power available. This is because all the farm implements using bullock power require a pair of bullocks. The bullock pairs on the representative farms are shown in Table III-1, page 36.

Bullock pairs on the representative farms were assumed to be available 250 hours per month. Multiplying the bullock pairs available by 250 gave values of 208, 229, 279, and 438 bullock pair hours for Farms 1, 2, 3, and 4, respectively. These monthly restrictions are used in all models.

Bullock power is also available for hire in the area and is assumed to be available to all farmers in unlimited quantity. Farmers in the survey reported that surplus bullock power was regularly hired out on other farms. The current rate for hiring a pair of bullocks with a driver was reported to range from Rs. 6.5 to Rs. 8.0 per eight hour day. Using the higher rate and assuming the driver's wage is Rs. 2.8 leaves Rs. 5.2 or Rs. 0.65 per hour as the rate for hiring a bullock pair. This rate, Rs. 0.65 per hour, is used in all the models and unlimited hired bullocks are assumed to be available.

There are also many water buffalo in the area that can be used as a partial substitute for bullocks. Generally buffalo, kept primarily for milk and manure, are used only for puddling paddy fields in the TBP area. However, in some parts of India buffalo are the major source of power for all farm operations. Occasionally, buffalo were seen in the TBP area pulling bullock carts. There appear to be large numbers of buffalo that could be used if bullocks were in short supply. However, buffalo were not considered in calculating the bullock power available.

Operating Capital

Operating capital in this study is defined to be the sum of cash on hand and cash obtained through borrowing. Since most farmers reported relatively little cash on hand as shown in Table III-1, page 36, credit becomes an important factor in the analysis.[15] Each cropping activity requires a certain amount of operating capital for purchase of seed, chemicals, fertilizer and farmyard manure. These inputs are referred to as cash expenses because generally they must be purchased by the farmers. Since cash on hand as reported in the survey appears to be very limited, the amount of credit available to meet cash expenses is very important.

In this study it is assumed that the minimum amount of operating credit available to farmers is the amount of the present total indebtedness as shown in Table III-1. An exception to this, however, is Farmer 4 who is obviously in a position to command more credit than his present indebtedness of Rs. 1914 would dictate. It was assumed that Farmer 4 could borrow Rs. 4000 as a minimum. The minimum amounts of credit available are Rs. 631, Rs. 1038, Rs. 2330, and Rs. 4000, for Farms 1, 2, 3, and 4, respectively. Also in some of the models, as pointed out later, unlimited operating credit was assumed for all farms.

The annual interest rates charged for borrowing operating credit were assumed to be 80 percent for Farmer 1, 50 percent for Farmers 2 and 3, and 30 percent for Farmer 4. However, operating credit used in crop

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[15] Although farmers talked freely about their debts they were hesitant to reveal their cash on hand. It is likely that the cash on hand figures were conservative estimates.

production is outstanding only six months which means farmers who borrow must actually pay only 40 percent, 25 percent, and 15 percent for the use of capital for the six months. Although these rates may seem excessively high, the survey indicates that moneylenders are supplying the majority of operating credit at rates ranging from 2 to 10 percent per month.

Also, since many moneylenders are often sellers of inputs and buyers of produce the farmer probably pays higher prices for inputs and receives lower prices for his products than at the cooperative. Since the input and output prices used were taken from government sources and are considered to be "fair" prices, the disadvantageous price position of farmers who trade with moneylenders is reflected in the high interest rates. In other words, although the nominal interest rate paid by farmers may be less than the rates used in the study, the real interest rate which includes the total cost of borrowing is probably as high as the rates used in the study.

The specific interest rates charged the various farmers are different because the survey indicates that some farmers are more dependent upon moneylenders than others. Farmer 1 is charged the highest rate because farmers in Stratum I were virtually all indebted to the moneylenders and no sources of institutional credit were reported. The sources of credit and amount owed indicated that, although the moneylender is the primary source of operating credit for all farmers, there is less dependency on moneylenders by Farmers 2 and 3 and even less by Farmer 4.

Implements

It was found that the basic farm implements were available in ample supply. Generally if a farmer owned a pair of bullocks, he also owned the implements needed for working the bullocks. In this study it was assumed that implements are not a constraint to production activities.

Cash Inputs

Cash inputs of seed, fertilizer, chemicals, and farmyard manure are assumed to be in ample supply and not a resource constraint. Actually, there probably are some shortages of these inputs. However, no attempt is made to determine and evaluate the shortages that may occur.

IV. DETERMINATION OF LAND USE LOCALIZATIONS

The Basis for Land Use Localizations

Land use localizations as a means of allocating water among farms have been adopted for the TBP. Although there are more sophisticated and probably more efficient methods of allocating water, they do not appear to be feasible for the TBP at this time. The more sophisticated methods generally require some means of measuring volume of water used at each farm. They also require an efficient system of communication throughout the irrigation area. The expense of installing meters at the farm level, the limited education level of the farmers, and the lack of modern communications in the TBP makes sophisticated methods of water allocation impractical at this time.

The land use localizations in the Fortieth Distributary as presently proposed are presented in Table II-2, page 15. However, the localizations are not being strictly enforced. The lack of strict enforcement results in more serious problems each year as the distributary becomes more fully developed. It is essential that enforcement of some set of localization regulations be implemented. TBP officials are now concerned about localization regulations and appear to be taking steps to implement their enforcement.

Land localizations determine which crops can be grown, to what extent they can be grown, and in which season they can be grown. Localization regulations are needed that comply with the broad objectives of the TBP and are also most beneficial to farmers. This study examines the likely results of two localization situations that are very similar to the proposed localization. It also examines other localization situations that have been suggested as alternatives to the proposed localization.

It was impossible to determine the exact manner in which the proposed localization regulations were determined. Thus, in this study the acres localized under each category of localization were determined using a technique commonly used by irrigation planners. The localizations in this study were determined by calculating the water requirements per acre of the crops during the specified seasons and then determining the number of acres that can be localized by using the water available for that season. The general guidelines for localization, as implied by the present localization regulations, were considered in setting up the localizations in this study.

Water Requirements for Paddy

In keeping with the guidelines for land localization, paddy is considered to be grown only in the *kharif* season. In all localization situations water for paddy cultivation is available for six months from June through November. The water requirement for paddy used by TBP planners was one cusec per 50 acres. Empirical studies indicate that one-half inch of water per day is adequate for growing paddy on black soils during the *kharif* season in the TBP.[16] One-half inch per day is the same as one cusec per 47.6 acres, and it is this rate rather than one cusec per 50 acres that is used. This rate of one-half inch per day meets the consumptive use requirement of paddy as well as the deep percolation losses associated with growing paddy on black soils.

Water Requirements of Light Irrigated Crops

Each light irrigated crop is likely to require a slightly different amount of water for optimum growth. However, it is impractical at this stage of development in the TBP, to localize lands for each crop with a different rate of water for each. Thus, the water requirements of all crops of four months duration are assumed to be the same if grown in the same season.

Irrigation planners have found that there is a fairly definite ratio of evapotranspiration (consumptive use) to pan evaporation for crops in various stages of growth. These ratios, consumptive use coefficients, have been calculated for various groups of crops with

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[16] Kester and Puttu Ram, "A Comparative Study," pp. 1-9.

comparable water requirements. Thus, if one knows the appropriate pan evaporation for a particular time period and location, he can calculate the consumptive use requirement for that time period and location for a particular crop by using the consumptive use coefficient. Average daily water requirements by month were used in this study to determine the amount of land that can be localized. The consumptive use coefficients for crop Group B were selected for use for all light irrigated crops because crops in Group B are most nearly comparable to the crops in this study.[17] The consumptive use coefficients for crop Group B for the four month crops and for cotton, a six month crop, are presented in Table III-2. These consumptive use coefficients are the average values for each month of the growing season.

Since actual pan evaporation data were not available for the TBP area, calculated pan evaporation rates were used. Mean daily pan evaporation rates by monthly periods have been calculated using climatic data for the TBP area by the Regional Pilot Project for Soil and Water Management. These rates are presented in Table III-3. These pan evaporation rates, when multiplied times the appropriate consumptive use coefficient from Table III-2, give the average daily consumptive use requirement for the appropriate month.

After calculating the average daily consumptive use requirement for each month, the average daily rainfall was subtracted to give the

[17]Consumptive use coefficients were calculated for eight crop groups by the Water Management Unit of the Indian Department of Agriculture. Crop Group B includes cotton, grain sorghum, and most of the other field crops in this study. Source: A Guide for Estimating Irrigation Water Requirements (New Delhi: Department of Agriculture, 1970), p. 10.

TABLE III-2

AVERAGE MONTHLY CROP CONSUMPTIVE USE COEFFICIENTS

Crop	Month of Growing Season	Consumptive Use Coefficient
Four Month Duration Crops	First	.355
	Second	.655
	Third	.695
	Fourth	.420
Six Month Duration Crops (Cotton)	First	.280
	Second	.540
	Third	.710
	Fourth	.730
	Fifth	.550
	Sixth	.290

Source: These coefficients were derived for Group B crops from: A Guide for Estimating Irrigation Water Requirements (New Delhi: Department of Agriculture, 1970), Table No. 8, p. 44.

TABLE III-3

CALCULATED MEAN DAILY PAN EVAPORATION RATES
FOR THE TBP AREA

Month	Calculated Mean Daily Pan Evaporation (Inches Per Day)
January	.290
February	.390
March	.490
April	.520
May	.540
June	.450
July	.400
August	.400
September	.370
October	.310
November	.275
December	.275

Source: These values were taken from Figure 4 of: Project Work Plan--Regional Pilot Project for Soil and Water Management, Bellary, Mysore State (Bangalore: Government of India, 1969), pp. 36-37.

average daily irrigation water requirement.[18] This value, the average daily irrigation water requirement, was used in determining the localizations. The average daily rainfall values used are presented in Table III-4. During the "heavy" rainfall months of August, September and October, only 80 percent of the average daily rainfall was assumed to be available because some water will be lost during high intensity rains. The average daily irrigation water requirements for the light irrigated localizations are presented in Table III-5.

The Irrigation Water Constraint

There are two possible constraints on irrigation water to the Fortieth Distributary. The first constraint is the total quantity of water that is available to the distributary and the time periods during which this quantity is available. The second constraint is the water carrying capacity of the Fortieth Distributary. The carrying capacity sets a maximum on the amount of water that can be used regardless of how much total water is available to the distributary.

Attempts to determine the first constraint, the total quantity of water available, were unsuccessful. However, certain general restrictions do exist regarding water availability and the season of availability. Although water has been available in large quantities for 11 months of the year in the LBLLC, it is very unlikely that this will continue. In

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[18]Average daily irrigation water requirement for a given month equals crop consumptive use coefficient (Table III-2) times calculated mean daily pan evaporation (Table III-3) minus average daily rainfall available (Table III-4).

TABLE III-4

AVERAGE DAILY RAINFALL AVAILABLE BY MONTH
IN THE TBP AREA

Month	Average Daily Rainfall Available in Inches
January	0
February	0
March	0
April	.03
May	.075
June	.061
July	.064
August	.080[a]
September	.118[a]
October	.109[a]
November	.043
December	.012

[a]Reflects only 80 percent of average daily rainfall.

Source: Calculated from data in: Project Work Plan--Regional Pilot Project for Soil and Water Management, Bellary, Mysore State (Bangalore: Government of India, 1969), p. 9.

TABLE III-5

CALCULATED AVERAGE DAILY IRRIGATION WATER REQUIREMENTS FOR LIGHT IRRIGATED CROPS UNDER VARIOUS LOCALIZATIONS

Localization	Average Daily Irrigation Water Requirement (in Inches)
Kharif (June-September)	
June	.098
July	.198
August	.198
September	.037
Rabi I (October-January)	
October	.001
November	.137
December	.178
January	.120
Cotton I (August-January)	
August	.030
September	.081
October	.111
November	.157
December	.138
January	.084
Rabi II (November-February)	
November	.055
December	.168
January	.200
February	.160
Cotton II (September-February)	
September	.000
October	.058
November	.152
December	.188
January	.159
February	.110
Summer (January-April)	
January	.103
February	.255
March	.340
April	.180

past years water has generally been in surplus because only a small percentage of total localized lands were developed. The original localization regulations provided for irrigation on the LBLLC only during <u>kharif</u> and <u>rabi</u> seasons. Only a very small amount of water was to be available during the summer season to serve the garden lands and sugarcane. Thus, for purposes of this study it is reasonable to assume that significant quantities of water will not be available for summer irrigations.

For this study it is assumed that total quantity of water available to the distributary is not a restriction during the period from June through January for Localization Situation I and June through February for Localization Situation II. Any exceptions to these assumptions are pointed out as the Localization Situations are presented.

The second constraint, the carrying capacity of the Fortieth Distributary, was determined. The size of the opening at the mouth of the distributary and the size of the ditches sets a maximum on the water that can be made available. According to PWD officials, the maximum flow that can be counted on for planning purposes on the Fortieth Distributary is 68 cusecs at the field level.[19] This rate of 68 cusecs is defined as the "normal maximum flow that can be used for planning purposes." This is the field level availability and does not include the 25 percent of total water entering the distributary that is considered to be lost due to seepage, evaporation and waste.[20]

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[19] Interview with Narasing Rao Madarkal, Deputy Administrator TBP, at Sindhanur, February 8, 1971.

[20] Interview with N. G. Joshi, Chief Engineer PWD, at Hospet, February 22, 1971.

Localization Situation I

Localization Situation I includes some land localized under each of these localizations: paddy, kharif, rabi I, cotton I. Garden lands are not considered in any of the localization situations in this study.

It was assumed that 677 acres of paddy would be localized in Localization Situation I. This is the same amount localized under the proposed localization for the Fortieth Distributary as presented in Table II-2, page 15. Since paddy requires one cusec per 47.6 acres, this amount of paddy will require a flow of 14.225 cusecs (677 ÷ 47.6 = 14.225) for the six month paddy irrigation period. Since the total flow available is 68 cusecs, this leaves 53.775 cusecs (68 - 14.255 = 53.775) available for light irrigation.

During the rabi I season the peak month of water requirement, as presented in Table III-5, page 51, is December with .178 inches per day. At this rate one cusec would supply 132.2 acres.[21] Since 53.775 cusecs[22] are available for light irrigation, then 7,109 (53.775 x 132.2) acres could be localized for rabi I crops. However, in keeping with localization guidelines as shown in Table II-2, approximately one-half as much land must be localized for cotton as for rabi. Thus, of the 7,109 acres

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[21]A flow of one cusec supplies one inch of water for 23.8 acres in one 24 hour day. Thus, one cusec supplies (23.8 ÷ .178 = 132.2) 132.2 acres with .178 inches in a 24 hour day.

[22]Since paddy irrigation terminates on November 30, it would be possible to have the full 68 cusecs available for light irrigation beginning December 1. However, it is assumed that only the 53.775 cusecs available during the kharif season and during October and November will be available for December and January light irrigation.

that could be localized for *rabi* I, 4,739 acres are localized for *rabi* I, and 2,370 acres are localized for cotton I.

Table III-5, page 51, shows that the requirement for cotton I during the *rabi* I months is less than .178 inches. Thus, the water requirements for cotton will be met during these four months. In September, cotton I requires .081 inches. Since *kharif* crops require only .037 inches in September, adequate water will be available for cotton. In August, the peak water use month for *kharif* crops, cotton requires .030 inches per day or one cusec per 793.3 acres. This means that 2.98 (2370 ÷ 793.3) cusecs will be required to meet the cotton I requirement during August. This leaves only 50.788 (53.775 - 2.98) cusecs available for *kharif* light irrigation.

The peak month of water requirement for *kharif* crops is August with .198 inches. This is the same as one cusec per 119 acres. Thus, the localization for *kharif* is 6,044 (50.788 x 119) acres. The localizations for Localization Situation I are presented in Table III-6.

The localizations shown in Table III-6 are distributed among the representative farms on the basis of total acres in each stratum. That is, farms in Stratum I receive a percentage of each category of localization equivalent to the percentage of total land owned by farmers in Stratum I. Farms in Stratum I receive 8.417 percent of all localizations, Stratum II farms receive 26.981 percent, Stratum III farms receive 27.418 percent, and Stratum IV farms receive 37.184 percent. Then the total localization for each stratum is divided by the number of farms in that stratum to get the average localization assignment for the representative

TABLE III-6

LOCALIZATIONS FOR LOCALIZATION SITUATION I
ON THE FORTIETH DISTRIBUTARY

Localization	Dates Water is Available	Localized Acres
Heavy Irrigation		
Paddy	June-November	677
Total Heavy Localization		677
Light Irrigation		
Kharif	June-September	6,044
Rabi	October-January	4,739
Cotton	August-January	2,370
Total Light Localization		13,153
Total Localization		13,830

farms. For example, Stratum I receives 8.417 percent of the localization or 1,164.06 (13830 x .08417) acres. Stratum I contains 223.913 farms so each farm, representative Farm 1, receives 5.198 (1164.06 ÷ 223.913) localized acres.

A review of distributary localizations revealed that roughly one-tenth of the survey numbers, that is, lands under a specific deed, had paddy localizations. Using this as a guide for distributing paddy localizations, it was found that if roughly one-tenth of the farmers in each stratum received one-half of their total localization in paddy, it would exhaust the paddy localization.

Since the majority of farms do not have paddy localizations, two representative farms are created for each stratum. That is, Farm 1 and Farm 1P are created to represent farms in Stratum I. These farms are exactly alike except Farm 1P receives a paddy localization and Farm 1 does not. Both Farms 1 and 1P have the same number of total localized acres but one-half of Farm 1P's localization is for paddy while all of Farm 1's localization is for light irrigation. The same is true for Farms 2, 2P, 3, 3P, and 4, 4P.

Table III-7 presents the localization assignments for the representative farms and the appropriate aggregation coefficient for each farm for Localization Situation I. The aggregation coefficient for Farm 1P means that Farm 1P is representative of 21.923 farmers on the Fortieth Distributary. The aggregation coefficient when multiplied times the acres, or any other factor, owned by the representative farm, gives the total acres owned by all representative farms in that category

TABLE III-7

LOCALIZATION ASSIGNMENTS AND AGGREGATION COEFFICIENTS FOR REPRESENTATIVE FARMS IN LOCALIZATION SITUATION I

Item	Representative Farm							
	1	1P	2	2P	3	3P	4	4P
Localization								
Paddy	0	2.599	0	3.124	0	5.862	0	8.599
Kharif	2.389	1.193	2.871	1.434	5.387	2.691	7.903	3.947
Rabi	1.873	.936	2.251	1.125	4.224	2.112	6.197	3.096
Cotton	.936	.468	1.126	.562	2.112	1.055	3.099	1.548
Total Localization	5.198	5.196	6.248	6.245	11.723	11.720	17.199	17.190
Aggregation Coefficient	201.990	21.923	538.634	58.469	291.766	31.664	269.722	29.275

throughout the Fortieth Distributary. These coefficients are used for aggregating to show total distributary production and input needs.

Localization Situation II

Localization Situation II includes some land localized under each of these localizations: Paddy, kharif, and rabi II. Cotton II was designed for Localization Situation II but was not needed as will soon be explained. Garden lands are not considered.

As in Localization Situation I, it was assumed that 677 acres of paddy would be localized. This leaves 53.775 cusecs available for light irrigation. The basic difference between Localization I and Localization II is that the rabi season, rabi II, begins on November 1, rather than on October 1, as in Localization Situation I. Also, since rabi irrigation begins a month later, it extends through February rather than January.

During the rabi II season, the peak month of water requirement as presented in Table III-5, page 51, is January with .200 inches. This is the same as one cusec per 119 acres which would allow a maximum of 6,399 (53.775 x 119) acres to be localized for rabi II. Although a cotton localization equal to one-half of the rabi localization would normally be assigned, there is no need for a cotton localization in Localization Situation II. Table III-5 shows that cotton II requires less than .200 inches during each of the four months of rabi II season. It also shows that cotton II does not require irrigation water during September. In October, cotton II requires .058 inches which can easily be supplied because kharif irrigation ceases on September 30 and water will be in surplus during October. Thus, in Localization Situation II there is no cotton localization, but cotton can be planted on rabi II localized lands. This means that the entire 6,399 acre rabi II localization could be planted in cotton if farmers chose to do so.

During kharif season, since cotton II does not require irrigation in September, the full 53.775 cusecs of water are available for light irrigation. The peak month of water requirement for kharif is August with .198 inches. This is one cusec per 119 acres, so 6,399 (53.775 x 119) acres can be localized for kharif. The localizations for Localization Situation II are presented in Table III-8.

Using the same procedures that were used in Localization Situation I, the localizations were allocated among the representative farms. These assignments are presented in Table III-9.

Localization Situation for Paddy Only

There has been some speculation, especially among farmers, that the localization regulations may be changed to use all the water for paddy. In order to evaluate the results of such a change, a localization situation using all the water for paddy is considered.

This localization would use the entire 68 cusecs for paddy for the six month period from June through November. Since one cusec supplies 47.6 acres, then 68 cusecs would supply 3,236.8 (47.6 x 68) acres. Thus, 3,236.8 acres of paddy can be localized on the Fortieth Distributary if all the water were used.

This localization is allocated among the representative farms in the same manner as was done in previously explained localizations.

TABLE III-8

LOCALIZATIONS FOR LOCALIZATION SITUATION II
ON THE FORTIETH DISTRIBUTARY

Localization	Dates Water is Available	Localized Acres
Heavy Irrigation		
Paddy	June-November	677
Total Heavy Localization		677
Light Irrigation		
Kharif	June-September	6,399
Rabi	November-February	6,399
Total Light Localization		12,798
Total Localization		13,475

TABLE III-9

LOCALIZATION ASSIGNMENTS AND AGGREGATION COEFFICIENTS FOR REPRESENTATIVE FARMS IN LOCALIZATION SITUATION II

Item	Representative Farm							
	1	1P	2	2P	3	3P	4	4P
Localization								
Paddy	0	2.599	0	3.124	0	5.862	0	8.599
Kharif	2.532	1.233	3.044	1.482	5.711	2.780	8.379	4.079
Rabi	2.532	1.233	3.044	1.482	5.711	2.780	8.379	4.079
Total Localization	5.064	5.065	6.088	6.088	11.422	11.422	16.758	16.757
Aggregation Coefficient	201.990	21.923	538.634	58.469	291.766	31.664	269.722	29.275

However, only four representative farms are used because all farms would receive paddy localization. The paddy localizations for Farms 1, 2, 3 and 4 are 1.217, 1.462, 2.744 and 4.025 acres, respectively.

Localization Situations I and II for Light Irrigation Only

In Localization Situation I, 14.225 cusecs were used for six months to irrigate 677 acres of paddy. If all this water were used for light irrigation, the 14.225 cusecs for six months would be spread over eight months and divided equally between *kharif* and *rabi* I. A flow of 14.225 for six months uses the same volume as a flow of 10.668 for eight months (14.225 x 6 = 10.668 x 8). Thus, an additional 10.668 cusecs were assumed to be available for *kharif* and *rabi* I localizations. Thus, the *kharif* localization is increased by 1,269 (119 x 10.668) acres to 7,313 (6,044, from Localization Situation I, plus 1,269) acres. The *rabi* I localization is increased by 1,410 (132.2 x 10.668) acres to 6,149 (4,739, from Localization Situation I, plus 1,410) acres. The cotton I localization was not changed from Situation I and remains at 2,370 acres.

The results of assigning these localizations to four representative farms are presented in Table III-10 along with the aggregation coefficients. Since there is no paddy localization, only four representative farms are used.

This same procedure was used for determining localizations for Localization Situation II with no paddy. *Kharif* localization is increased by the same amount, 1,269 acres, as it was in the previous computation. This gives a *kharif* localization of 7,668 (6,399, from

TABLE III-10

LOCALIZATION ASSIGNMENTS AND AGGREGATION COEFFICIENTS FOR REPRESENTATIVE FARMS WHEN ALL WATER IS USED FOR LIGHT IRRIGATION IN LOCALIZATION SITUATION I

Item	Representative Farm			
	1	2	3	4
Localization				
Kharif				
Rabi	2.749	3.304	6.199	9.095
Cotton	2.311	2.778	5.217	7.647
Total Localization	.891	1.071	2.009	2.947
	5.951	7.153	13.425	19.689
Aggregation Coefficient	223.913	597,103	323.430	298.997

Localization Situation II, plus 1,269) acres. Rabi II localization also increases by 1,269 acres because one cusec is required per 119 acres in both kharif and rabi II. This gives a rabi II localization of 7,668 acres.

When localization assignments are made to the four representative farms, each farm has an equal amount of kharif and rabi II localizations. The assignments for Farms 1, 2, 3 and 4 are 2.88, 3.46, 6.50, and 9.53 acres of kharif and rabi II localizations, respectively. The aggregation coefficients are the same as those in Table III-10.

Localization Situation for Summer Light Irrigation

Although it seems rather unlikely, there is some speculation that the localization regulations will be changed to allow paddy irrigation during the kharif season and light irrigation during the summer from January through April. This system has been adopted on the RBLLC.

In constructing this localization situation, it is assumed that eight months of water at 68 cusecs are available. Four of these months are January through April. The other four months at 68 cusecs are converted to six months flow at 45.33 cusecs, that is, 68 x 4 = 45.33 x 6. These six months are June through November and are used for paddy cultivation.

Thus, the total localization for paddy is 2,158 (45.33 x 47.6 acres per cusec) acres. The light localization is determined from Table III-5, page 51. The peak month of water requirement for summer light irrigation is March with .340 inches. This is the same as one cusec per 70 acres. Thus, the summer localization is 4,760 (68 x 70) acres.

When these localizations are assigned to the representative farms, each farm receives some paddy and some summer localization. Four representative farms are used. Their localizations are: Farm 1, 1.789 summer and .811 paddy; Farm 2, 2.151 summer and .975 paddy; Farm 3, 4.035 summer and 1.829 paddy; Farm 4, 5.919 summer and 2.683 paddy. The aggregation coefficients are the same as in Table III-10, page 63.

Summary of Localization Situations

There are six alternative localization situations considered in this study. The construction and specific details of these localization situations has been described. Localization Situations I and II are the most comparable to the proposed localizations for the Fortieth Distributary. The basic difference between Localization Situation I and Localization Situation II is that there is a lapse of one month, October, between the end of *kharif* irrigation and the beginning of *rabi* irrigation for Localization Situation II. In Localization Situation I *rabi* irrigation commences immediately at the end of *kharif* irrigation.

In the Paddy Only Localization Situation all available water is used for paddy and no light irrigation is permitted. The Light Irrigation Only Localization Situations I and II are patterned after Localization Situations I and II except all water is used for light irrigation and no paddy is allowed. The Localization Situation for Summer Light Irrigation allows only light irrigation during the summer and allows paddy during *kharif* season.

V. ACTIVITIES IN THE MODEL

The Objective Function

The objective function consists of the income generating activities and other activities incidental to production. The only income generating activities considered are crop production activities. The only livestock production in the Fortieth Distributary is the keeping of buffalo for home consumption of milk and a few scattered goat herds. Livestock production does not appear to be important enough to warrant consideration.

In all the models it is assumed that the farmers' objective is to maximize net returns to family labor, land, management, and capital invested in bullocks and implements. Thus, the linear program was run for maximization of net returns as defined above. Net returns for the purposes of this study may also be called net income.

Linear programming is used to maximize net income on the representative farms subject to the resource limitations as reflected by resource availabilities on the representative farms. Algebraically, the maximization model, sometimes called the maximization primal, can be represented as:

$$Z_{max} = \sum_{j=1}^{n} C_j X_j$$

subject to:

$$(1) \quad \sum_{j=1}^{n} a_{ij} X_j \leq b_i \quad (\text{for all } i = 1, 2, \ldots, m)$$

$$(2) \quad X_j \geq 0 \quad (\text{for all } j = 1, 2, \ldots, n)$$

where

Z_{max} = net income,

C_j = the known amount of net income per unit (acre) of X_j produced,

X_j = the unknown amount of output (acres) for 1, 2, ..., n possible outputs,

a_{ij} = known amount of the i^{th} resource required to produce one unit (acre) of the j^{th} product, and

b_i = the known availability of the i^{th} resource for i = 1, 2, ..., m resources.

Since net income is maximized, the objective function coefficients for the crop activities reflect the net incomes per acre for each crop. To obtain the crop coefficients, the total variable expenses per acre were subtracted from total revenue per acre. The total variable expenses are defined to include the "cash" variable expenses and the "noncash" variable expenses. The cash variable expenses include expenditure on seed, farmyard manure, fertilizer and chemicals. The noncash variable expenses include depreciation and repairs on implements. The noncash variable expenses are a negligible portion of total variable expenses.

Family labor and owned bullock power are not included as variable expenses in calculating the objective function coefficients. These inputs are assumed to be "fixed" to the farm and thus "free" inputs to the extent that they are available. Activities for hiring additional labor and bullock power are included at the appropriate rate. The crop budgets which show the total revenues, expenses and net returns (objective function coefficients) for each crop considered are presented in Tables A-1 through A-12, Appendix B.

The activities in the objective function, other than the income generating crop activities, are hiring labor, hiring bullocks, and borrowing operating credit. Other activities such as using paddy localization for light irrigation and using cotton localization for rabi crops are allowed as required under the various localization situations.

Selection of Crop Activities

Crops selected for inclusion in the model were selected after numerous discussions with agricultural officials and farmers. The crops selected are believed to be the most profitable crops presently grown in the black soil areas. Crops that may be profitable but are not presently grown to a significant extent on the black soils are not considered. The lack of input-output data under farm conditions and the lack of established markets precludes the consideration of crops that are not presently being grown to some extent on the black soils. The crops selected for consideration are: paddy (Oryza sativa), jowar (Sorghum vulgare), wheat (Triticum aestivum), navane (Setaria italica), bajra (Rennisetum typhoides), cotton (Gassypium hirstum), and safflower (Carthamus tinctorius).

Several crops that are sometimes grown on the black soils are not considered in this study. They are not considered because they were not recommended by researchers and farmers as being among the more profitable crops or because markets for these crops are not well established. The pulse crops, castor, coriander, groundnut, the perishable vegetable crops, and others are not considered. Although certain farmers may specialize in these crops and consider them to be profitable, they do not appear to have the profitability or market potential to justify their consideration in this study.

Mixed cropping, the growing of two or more crops in the same row or in alternate rows in the same field, is not considered. The primary purpose of mixed cropping appears to be to reduce the risk of total crop failure under dryland conditions. With irrigation becoming prevalent, mixed cropping is likely to become less important.

The Dryland Crops

Dryland (rainfed or nonirrigated) crops are considered only during the rabi season. Although some kharif dryland crops are grown, the common practice is to take advantage of the "heavy" rains by planting dryland crops in September. The great majority of the farmers in the survey reported growing dryland crops only in late kharif or rabi season.

The dryland crops are jowar, cotton, wheat, and safflower. Since all of these crops are also grown under irrigation, further information will be given in the section on light irrigated crops.

Paddy

Although paddy can be grown in any season, the localization regulations limit it to the kharif season. Only one variety, IR-8, is considered. The bulk of evidence at this time suggests that IR-8 paddy is more profitable than the improved local varieties. IR-8 has consistently higher yields which generally more than make up for the lower price received for IR-8 because it is not the preferred table rice. It is likely, however, that improved local varieties will continue to be grown to some extent.

The input requirements for IR-8 and the improved local varieties are very similar and for planning purposes there is no need to distinguish between them. Since input differences are minor, it would be useless to include both local and IR-8 in the program because IR-8 would always be grown because of its profitability. The main difference in input requirements is that IR-8 requires slightly more labor for transplanting because it is planted thicker than the local variety.

The Light Irrigated Crops

Hybrid jowar (CSH-1) or grain sorghum is considered for kharif and summer irrigation and high-yielding-variety jowar (M35-1) is considered for rabi irrigation and dryland. Jowar requires 100 to 110 days to mature which makes it suitable for four months of irrigation. Jowar is a staple food in the TBP area.

Hybrid bajra (HB-1) or pearl millet is considered during kharif and summer seasons only. It is susceptible to disease during rabi season. Its duration of 80 to 90 days makes it very desirable as the first crop in double cropping schemes.

Navane or foxtail millet can be grown in kharif, rabi or summer. No particular variety is specified. Most improved local varieties are satisfactory. It has a four month duration.

Mexican wheat of the Lerma Rojo and Safed Lerma varieties has proved to be well adapted to black soils. A major limitation is that wheat can be grown only during rabi season under irrigation or dryland. It has a four month duration.

Safflower, varieties A-300 or 13-3-4, is grown only in the rabi season. Safflower has done well as a drought resistant dryland crop and is now being cultivated on a large scale under irrigation. Safflower with a duration of slightly more than four months must be planted promptly at the beginning of the rabi irrigation.

Although several new hybrid varieties of cotton are being tried, the relatively new but proved high-yielding-variety of hampi cotton is considered. Cotton can be grown only during the rabi season. It has a duration of six months and can be grown under irrigated or dryland conditions.

All the single crops and the seasons in which they may be grown are presented in Table III-11. In the specific models the seasons in which irrigated crops are allowed are determined by the localization situation. For example, summer cropping is allowed only in the summer localization situation.

Physical Demarcation and Localization Trading

Before discussing the double cropping activities, two characteristics of the scheme of land use localizations need explanation. These characteristics were not explained earlier because they are mainly pertinent to double cropping. These characteristics are: (1) the lack of a physical demarcation of light localized lands as to which specific acres

TABLE III-11

SINGLE CROPS AND THE SEASONS IN WHICH THEY MAY BE GROWN UNDER DRYLAND AND IRRIGATED CONDITIONS

Crop	Season		
	Kharif	Rabi	Summer
Dryland Crops			
Safflower	No	Yes	No
Wheat	No	Yes	No
Cotton	No	Yes	No
Jowar	No	Yes	No
Heavy Irrigated Crops			
Paddy	Yes	No	No
Light Irrigated Crops			
Safflower	No	Yes	No
Wheat	No	Yes	No
Cotton	No	Yes	No
Jowar	Yes	Yes	Yes
Bajra	Yes	No	Yes
Navane	Yes	Yes	Yes

are kharif, rabi and cotton,[23] and (2) the concept of "trading" or the using of a particular localization for a different purpose than its name would imply.

There is a physical demarcation of lands localized for paddy because paddy lands are in blocks. There is also physical demarcation as to the total area localized for light irrigation. However, within this total area localized for light irrigation on a particular farm, there is no physical demarcation as to which specific area is for kharif, cotton or rabi. For example, if a farmer owned six acres localized for light irrigation, the TBP localization maps would show which six acres were localized. However, these six acres are composed of kharif, rabi and cotton localizations, but there is no physical demarcation on the map showing which specific acres are kharif, rabi and cotton. Thus, the farmer has the privilege of growing crops up to the limit of his kharif, rabi and cotton localizations on any of the six acres he chooses.

The concept of "trading" is used to describe how a farmer may trade one localization for another among the localizations on his own farm.[24] No trading is allowed between farms or farmers. Because of the inflexibility of localization regulations, trading is always done for a lesser amount of total water. That is, a farmer always gives up more total water authorization than he receives when he trades. Only three

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[23] Interview with Narasing Rao Madarkal, Deputy Administrator TBP, at Sindhanur, February 8, 1971.

[24] The term "trading" was not used in the TBP. It is used here to describe what farmers in practice are allowed to do with their localizations.

trading activities are allowed and, again, a farmer actually trades only with himself. The three trading activities are: (1) the trading of one acre of cotton localization for one acre of _rabi_ localization, (2) the trading of one acre of _kharif_ and one acre of _rabi_ for one acre of cotton, and (3) the trading of one acre of paddy localization for one acre of _kharif_ light localization.

In trading cotton for _rabi_, the farmer gives up six months water authorization for four months at the same water rate. In trading one _kharif_ and one _rabi_ for one cotton, he gives up eight total months of water for six months at the same rate. In trading one paddy for one _kharif_ he gives up six months at a heavy flow for four months of lighter flow. Thus, in every trade the farmer gives up more water than he receives. To allow trading in any manner but these three ways would make the system of land use localizations unenforceable. Also to allow trading between farms would make the system very difficult to enforce. However, once the farmers become adjusted to strict localization enforcement and the PWD becomes adept at enforcement there may be scope for trading between farms and trading of water on a volume basis rather than a localization basis as is done here.

Several examples are given to show the implications of the characteristics described above. In all examples we assume the farmer has six acres demarcated for light irrigation and has localization authorizations for three acres of _kharif_, two acres of _rabi_ and one acre of cotton.

Example 1. In this example, the farmer grows three acres of kharif crop on one three acre section, two acres of rabi crop on a different two acre section and one acre of cotton on the remaining one acre section. He uses the entire six acres of land and all of his localizations. He does not double crop or trade. He must develop the entire six acres for irrigation.

Example 2. In this example, the farmer grows three acres of kharif crop on a three acre section, harvests it rapidly, and grows two acres of rabi crop on two of the same three acres. He grows an acre of cotton on a different acre because kharif crops cannot be harvested in time for following with cotton. By double cropping he uses all of his localizations but uses only four total acres. This leaves two acres for dryland crops. He must develop only four acres for irrigation. He does no trading here.

Example 3. In this example, by double cropping and trading an acre of cotton for an acre of rabi localization the farmer grows three acres of kharif crop, harvests it rapidly and grows three acres of rabi crop on the same land. He uses all of his localizations, but gives up an acre of cotton for an acre of rabi. Here, he requires only three developed acres.

Example 4. In this example the farmer prefers cotton and trades two acres of kharif and two acres of rabi for two acres of cotton. This gives him three acres of cotton and one of kharif and requires four acres of land with no double cropping.

Double Cropping

The double cropping activities allowed are simply combinations of two single crops. Inputs and outputs for a double crop are the sum of inputs and outputs for the two single crops. Thus, the sum of labor requirements for the two single crops equals the labor requirement for the double crop. However, in the double crop situation the months in which certain operations are performed will not be the same as if the two crops were grown singly. For example, kharif crops must be harvested in the month of maturation if they are to be followed by rabi crops. If kharif crops are grown singly, however, they will usually be harvested in the month following maturation. Since monthly labor requirements for double cropping activities are not the sum of the monthly labor requirements of the two crops grown singly, separate activities must be included in the program for each double cropping combination.

The double cropping activities and the localization situations in which they are allowed are presented in Table III-12. Bajra is the only kharif crop allowed to be double cropped in Localization Situation I. This is because the other light irrigated kharif crops require the full four months of irrigation and cannot be harvested in time to plant rabi crops. Localization Situation II allows a much wider range of double cropping activities. Cotton, either irrigated or dryland, is not allowed in double cropping activities because of its six month duration.

Input Requirements and Crop Yields

Only one output level is considered for each crop. This level of output is defined as "an output level that a farmer could reasonably

TABLE III-12

DOUBLE CROPPING ACTIVITIES AND THE LOCALIZATION SITUATIONS IN WHICH THEY ARE ALLOWED

Double Crop Combination				Localization Situation I	Localization Situation II	Summer Light Irrigation
Irrigated Kharif	Irrigated Rabi	Dryland Rabi	Irrigated Summer			
Bajra	Wheat			Yes	Yes	No
Bajra	Safflower			Yes	Yes	No
Bajra	Jowar			Yes	Yes	No
Bajra	Navane			Yes	Yes	No
Bajra		Wheat		Yes	Yes	No
Bajra		Safflower		Yes	Yes	No
Bajra		Jowar		Yes	Yes	No
Jowar	Wheat			No	Yes	No
Jowar	Safflower			No	Yes	No
Jowar	Jowar			No	Yes	No
Jowar	Navane			No	Yes	No
Navane	Wheat			No	Yes	No
Navane	Safflower			No	Yes	No
Navane	Jowar			No	Yes	No
Navane	Navane			No	Yes	No
Paddy			Bajra	No	No	Yes
Paddy			Jowar	No	No	Yes
Paddy			Navane	No	No	Yes

expect if he used good cultural practices, adequate irrigation water (or normal rainfall under dryland conditions), and fertilizer dosages recommended by research stations and progressive farmers." Likewise, only one level of inputs is allowed.

The crop budgets, presented in Tables A-1 through A-12, Appendix B, give the inputs required, input prices, output and output prices and the net returns (objective function coefficients) per acre for the single crops. The values for the double crops are simply the sums of the single crops used in the double crop combination. All units of measure used in the crop budgets are metric system measures.[25] The implement depreciation and repair costs on which the noncash variable expenses are based are presented in Table A-13, Appendix B. The labor and bullock power requirements for the various crops are presented in Table A-14, Appendix B.

No water charges are included in the crop budgets. The present duty is Rs. 16 per acre for heavy irrigation and Rs. 8 per acre for light irrigation. There is also an annual charge of Rs. 4 per acre for maintenance. The duty is ultimately to be levied on all farmers according to their land localizations, whether or not they make use of the water.[26] This means water charges will ultimately become a fixed expense and for this reason were not included in the crop budgets.

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[25]Measures used are the kilogram (Kg.), quintal (Q.) and metric ton. One kilogram equals 2.204 pounds. One quintal equals 220.4 pounds or 100 kilograms. A metric ton equals 2204 pounds, ten quintals or 1000 kilograms.

[26]Interview with R. Basavaraj, Sindhanur Taluk Revenue Officer, at Sindhanur, December 11, 1970.

It has been suggested by some officials that duties be set at different rates for each localization, and that the charge not be fixed. Any assumption made here about the rate that should be charged for each localization, under such a system, is likely to be incorrect. Thus, this is also a reason for not including water charges. However, the results of this study could be helpful in determining appropriate rates that could be charged, based on the value of each localization to the farmers when there is no water charge.

CHAPTER IV

ANALYSIS OF RESULTS ON REPRESENTATIVE FARMS

In discussing the most profitable crops on the representative farms, a totally microeconomic approach is taken. Thus, in the sections on crop profitability, no attention is given to the total distributary results. In the sections regarding aggregate production for the distributary, the macroeconomic problems are considered.

For purposes of this study, the most profitable crops are defined to be those crops that are grown by representative farmers who are maximizing their net incomes. Net income is defined as the returns to family labor, land, management, and capital invested in bullocks and implements.

Although six alternative localization situations were described in Chapter III, only the results under Localization Situations I and II are reported in the microeconomic analysis. The main purpose of this analysis is to determine the relative profitability of the various crops grown on representative farms. Localization Situations I and II are most comparable to the proposed localization regulations for the Fortieth Distributary and the results under these localization situations are the most meaningful because of the large variety of crops that is allowed to be grown.

The microeconomic results of the linear programming analyses under the Light Irrigation Only Localization Situations I and II yielded virtually the same results as on those farms without paddy localizations in Localization Situations I and II, respectively. Thus, these results are not reported. In the Paddy Only Localization Situation, paddy is the only irrigated crop allowed and, therefore, the results are not very meaningful. The linear programming analysis for the Summer Light Irrigation Localization Situation was done only for purposes of showing aggregate production and, therefore, an analysis of crops is not presented.

I. CROPS GROWN UNDER LOCALIZATION SITUATION I

The Models Considered

Three models were run for each representative farm under Localization Situation I. These models are: (1) Model 1, the limited operating capital model, (2) Model 2, the unlimited operating capital model, and (3) Model 3, the unlimited operating capital and unlimited developed land model. Throughout the analysis these models are referred to as Model 1, Model 2, and Model 3.

In Model 1, the limited operating capital model, operating credit is limited to the amount of the present indebtedness of the representative farmers as shown by the survey. Representative Farm 4 and Farm 4P, however, are allowed Rs. 4000 of credit rather than the amount of their indebtedness.[1] All other resources are available to the farmers as determined by the survey.[2] Hired labor and hired bullock power are available in unlimited amounts.

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[1]The basis for credit available is given on page 41.

[2]The construction of representative farms and their resources is presented in Chapter III, pages 34 through 43.

In Model 2, the unlimited capital model, all resources are the same as in Model 1, except unlimited operating credit is available to all farmers. In Model 3, the unlimited operating capital and unlimited developed land model, all resources are the same as in Model 1 except both unlimited credit and unlimited developed land are available.

Model 1 shows the likely results in the present situation if credit is limited. Model 2 shows the likely results in the present situation if credit is unlimited. Model 3 shows the likely results in a future situation where the distributary is fully developed and credit is unlimited.

Profitable Crops on Farms 1 and 1P

Data derived from the budgets for the various crops, showing the net incomes per acre (the objective function coefficients), the cash expenses, and the net income per rupee of cash expense are presented in Table IV-1. Information in this table is referred to several times in the analysis. The results of linear programming Models 1, 2, and 3 for Farmers 1 and 1P under Localization Situation I are presented in Table IV-2.

In Model 1, Farmers 1 and 1P have no developed land and their only crop choices are the dryland crops. Both farmers do exactly the same thing, that is, each grows 9.266 acres of dryland cotton. Table IV-1 shows that dryland cotton has lower net returns than either dryland _jowar_ or safflower. However, the table also shows that dryland cotton requires the least cash expenses of all crops and has the highest net income per rupee of cash expense. Since operating capital was the only

TABLE IV-1

NET INCOME PER ACRE, CASH EXPENSES PER ACRE, AND NET INCOME PER RUPEE OF CASH EXPENSE FOR CROPS CONSIDERED IN THE STUDY

Crop	Net Income Per Acre	Cash Expenses Per Acre	Net Income Per Rupee of Cash Expense
	Rupees		
Dryland Crops			
Cotton	266.5	69.4	3.84
Safflower	271.3	78.5	3.45
Wheat	139.5	134.0	1.04
Jowar	301.0	110.8	2.72
Irrigated Crops			
Paddy	787.1	349.8	2.25
Kharif Jowar	549.9	277.3	1.98
Kharif Bajra	330.9	221.6	1.49
Kharif Navane	286.9	216.6	1.32
Cotton	719.8	251.2	2.87
Rabi Jowar	553.7	273.5	2.02
Rabi Navane	286.9	216.6	1.32
Rabi Safflower	535.3	166.9	3.21
Rabi Wheat	660.5	334.9	1.97

TABLE IV-2

SELECTED RESULTS OF THREE MODELS FOR FARM 1 AND FARM 1P UNDER LOCALIZATION SITUATION I

Item	Unit	Model 1		Model 2		Model 3	
		Farm 1	Farm 1P	Farm 1	Farm 1P	Farm 1	Farm 1P
Net Income	Rs.	2,217	2,217	3,046	3,046	4,470	4,773
Total Land	Ac.	11.849	11.849	11.849	11.849	11.849	11.849
Total Land Used	Ac.	9.266	9.266	11.849	11.849	11.849	11.849
Developed Land	Ac.	--	--	--	--	UL[a]	UL
Developed Land Used	Ac.	NA[b]	NA	NA	NA	3.325	4.260
MVP of Developed Land	Rs.	--	--	512	512	--	--
Paddy Localization	Ac.	--	2.599	--	2.599	--	2.599
Paddy Localization Used	Ac.	NA	--	NA	--	NA	2.599
MVP of Paddy Localization	Rs.	--	--	--	--	391	391
Kharif Localization	Ac.	2.389	1.193	2.389	1.193	2.389	1.193
Kharif Localization Used	Ac.	--	--	--	--	2.389	1.193
MVP of _Kharif_ Localization	Rs.	--	--	--	--	242	242
Rabi Localization	Ac.	1.873	.936	1.873	.936	1.873	.936
Rabi Localization Used	Ac.	--	--	--	--	1.873	.936
MVP of _Rabi_ Localization	Rs.	--	--	--	--	270	270
Cotton Localization	Ac.	.936	.468	.936	.468	.936	.468
Cotton Localization Used	Ac.	--	--	--	--	.936	.468
MVP of Cotton Localization	Rs.	--	--	--	--	363	363

TABLE IV-2 (continued)

Item	Unit	Model 1		Model 2		Model 3	
		Farm 1	Farm 1P	Farm 1	Farm 1P	Farm 1	Farm 1P
Credit Available	Rs.	631	631	UL	UL	UL	UL
Credit Used	Rs.	631	631	1,300	1,300	2,381	2,461
MVP of Credit	Rs.	3.44	3.44	--	--	--	--
Crops							
Paddy	Ac.	--	--	--	--	--	2.599
Irrigated Cotton	Ac.	--	--	--	--	.936	.468
Dryland Cotton	Ac.	9.266	9.266	--	--	--	--
Dryland Jowar	Ac.	--	--	11.849	11.849	8.524	7.589
Irrigated Kharif Bajra and Irrigated Rabi Wheat	Ac.	--	--	--	--	1.873	.936
Irrigated Kharif Bajra and Dry Jowar	Ac.	--	--	--	--	.516	.257

[a] UL means unlimited.

[b] NA means not applicable.

limiting resource in Model 1, we can safely say that dryland cotton is the most profitable crop because it has the highest returns per rupee of cash inputs required.

The marginal value products (MVP's) for all resources except credit are zero. The MVP or shadow price for credit is Rs. 3.44. This means that one additional rupee of credit would increase net income by Rs. 3.44.[3] Credit is so limiting in this case that these farmers cannot cultivate all of their land. If credit is really as limiting as it is assumed to be in this model, then this may explain why many farmers grow the local varieties and use very few cash inputs. In actual practice these farmers might use a lower level of inputs per acre than they are allowed to use in this study. In this way they could use all of their land but at lower input levels per acre.

In Model 2, Farmers 1 and 1P again grow the same crops. Each grows 11.849 acres of dryland jowar. They more than double their credit use from Model 1 to Rs. 1300. Table IV-1 shows that dryland jowar has the highest net income per acre of the dryland crops. The MVP of Rs. 512 for developed land, from Table IV-2, indicates that it would be profitable to develop land.[4] However, if capital is really as limited to these farmers as it was in Model 1, then limited capital yields

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[3]The MVP shows the amount by which the objective function would increase if the respective input were increased by one unit over a certain range. We do not know what this "range" is and, therefore, must interpret the implications of MVP's cautiously.

[4]Farmers reported in the survey that land could be developed for Rs. 300 to Rs. 500 per acre.

higher returns when invested in crop inputs. If capital is very limited then this may explain why these farmers have not developed any land. Table IV-1, page 83, shows that returns per rupee invested in cash inputs is generally higher for dryland crops than for irrigated crops.

In Model 3 the unlimited capital and unlimited developed land model, Farmers 1 and 1P use their localizations in the same manner. That is, Farmer 1P uses all of his paddy localization for paddy and both farmers use all cotton localization for cotton, all rabi land for double cropping and the excess kharif land is used for double cropping with irrigated bajra and dryland jowar. Here the entire rabi localization is combined with a like amount of kharif localization and used for double cropping of irrigated bajra followed by irrigated wheat. Both farmers grow dryland jowar on the nonirrigated land.

Both farmers have a MVP for paddy localization of Rs. 391 as shown in Table IV-2, page 84. The highest MVP for both farmers is for paddy localization. Credit used in Model 3 is almost twice as much as in Model 2. This indicates the increases in cash expenses than can occur when irrigated farming is adopted.

Profitable Crops on Farms 2 and 2P

The results on Farms 2 and 2P under Localization Situation I are presented in Table IV-3. In Model 1 the results for Farmers 2 and 2P are the same. They do not exhaust any of their localizations and, therefore, the MVP's are zero. The only limiting resource is credit with a MVP of Rs. 2.24. Only .517 acres of the developed land is used.

TABLE IV-3

SELECTED RESULTS OF THREE MODELS FOR FARM 2 AND FARM 2P UNDER LOCALIZATION SITUATION I

Item	Unit	Model 1		Model 2		Model 3	
		Farm 2	Farm 2P	Farm 2	Farm 2P	Farm 2	Farm 2P
Net Income	Rs.	3,754	3,754	5,505	5,005	5,805	6,186
Total Land	Ac.	14.244	14.244	14.244	14.244	14.244	14.244
Total Land Used	Ac.	14.244	14.244	14.244	14.244	14.244	14.244
Developed Land	Ac.	1.983	1.983	1.983	1.983	UL[a]	UL
Developed Land Used	Ac.	.517	.517	1.983	1.983	4.128	5.120
MVP of Developed Land	Rs.	--	--	578	426	--	--
Paddy Localization	Ac.	--	3.124	--	3.124	--	3.124
Paddy Localization Used	Ac.	NA[b]	--	NA	.549	NA	3.124
MVP of Paddy Localization	Rs.	--	--	--	--	442	426
Kharif Localization	Ac.	2.871	1.434	2.871	1.434	2.871	1.434
Kharif Localization Used	Ac.	--	--	1.983	1.434	2.871	1.434
MVP of _Kharif_ Localization	Rs.	--	--	--	--	248	276
Rabi Localization	Ac.	2.251	1.125	2.521	1.125	2.251	1.125
Rabi Localization Used	Ac.	.091	.091	1.983	1.125	2.251	1.125
MVP of _Rabi_ Localization	Rs.	--	--	--	153	312	304
Cotton Localization	Ac.	1.126	.562	1.126	.562	1.126	.562
Cotton Localization Used	Ac.	.426	.426	--	.562	1.126	.562
MVP of Cotton Localization	Rs.	--	--	--	153	374	384

TABLE IV-3 (continued)

Item	Unit	Model 1 Farm 2	Model 1 Farm 2P	Model 2 Farm 2	Model 2 Farm 2P	Model 3 Farm 2	Model 3 Farm 2P
Credit Available	Rs.	1,038	1,038	UL	UL	UL	UL
Credit Used	Rs.	1,038	1,038	2.426	2,364	2,843	2,937
MVP of Credit	Rs.	2.24	2.24	--	--	--	--
Crops							
Paddy	Ac.	--	--	--	.296	--	3.124
Irrigated Cotton	Ac.	.426	.426	--	--	1.126	.562
Irrigated *Rabi* Safflower	Ac.	.091	.091	--	--	--	--
Dryland Cotton	Ac.	13.727	13.727	--	--	--	--
Dryland *Jowar*	Ac.	--	--	12.261	12.261	10.116	9.124
Irrigated *Kharif* *Bajra* and Irrigated *Rabi* Wheat	Ac.	--	--	1.983	1.687	2.120	1.125
Irrigated *Rabi* Wheat	Ac.	--	--	--	--	.131	--
Irrigated *Kharif* *Bajra* and Dry *Jowar*	Ac.	--	--	--	--	.751	.309

[a]UL means unlimited.

[b]NA means not applicable.

This indicates that in limited capital situations the dryland crops are generally more profitable.

Except for .091 acres of irrigated safflower, cotton is the only crop grown and is grown under irrigation and dryland. Table IV-1, page 83, shows that dryland cotton has the highest return per rupee invested of all crops and irrigated cotton is second only to safflower in returns per rupee invested of the irrigated crops.

In Model 2 Farmer 2 does not exhaust any of his localizations but uses all of his developed land. He double crops all of his developed land with irrigated bajra followed by irrigated wheat. The only dryland crop grown is jowar. The MVP of developed land is Rs. 578 which shows the profitability of developing more land. Irrigated bajra followed by irrigated wheat yields the highest returns of the double crops allowed in Localization Situation I.

Farm 2P in Model 2 as shown in Table IV-3 uses all of his developed land and exhausts his rabi and cotton localizations. The kharif localization is all used but not really "exhausted" because surplus paddy localization is available that can be traded for kharif. The MVP of kharif would probably not be zero if paddy lands were not available for trading for kharif. Actually, .253 acres of the .549 acres of paddy localization used were traded for kharif and only .296 acres were used for paddy. Farmer 2P trades his cotton localizations for rabi to give him a total of 1.687 acres of rabi. He double crops to the extent of his "new" rabi localization. The fact that some paddy was traded for kharif indicates that where developed land is limited the double cropping of two light irrigated crops may be more profitable than the single crop of paddy.

In Model 3, Farmers 2 and 2P use all of their land localizations. Both farmers use their cotton localizations for irrigated cotton. Except for .131 acres of irrigated wheat grown by Farmer 2, both farmers grow the same light irrigated crops but in different amounts as allowed by their localizations. Both farmers have their highest MVP for paddy localization.

Profitable Crops on Farms 3 and 3P

The results for Farmers 3 and 3P are presented in Table IV-4. In Model 1 neither farmer exhausts his total land or his developed land. Farmer 3 exhausts his cotton localization but not his kharif or rabi localizations. The surplus kharif and rabi localizations, which can be combined and traded for cotton, explain the MVP of zero for cotton localization shown in Table IV-4 for Farmer 3. Both farmers trade for cotton localization and the only crops grown are dryland and irrigated cotton.

In Model 2 Farmers 3 and 3P both grow as much double cropped irrigated bajra followed by irrigated wheat as possible. Farmer 3's limitation to growing this double crop is developed land. Farmer 3P's limitation is acres of rabi localization. Farmer 3 has MVP's of zero for all resources shown in Table IV-4 except developed land. Farmer 3P has positive MVP's for developed land, rabi, and cotton localizations. Both cotton and rabi have MVP's of Rs. 122 which indicates that this

TABLE IV-4

SELECTED RESULTS OF THREE MODELS FOR FARM 3 AND FARM 3P UNDER LOCALIZATION SITUATION I

Item	Unit	Model 1		Model 2		Model 3	
		Farm 3	Farm 3P	Farm 3	Farm 3P	Farm 3	Farm 3P
Net Income	Rs.	7,361	7,302	9,336	9,188	10,026	10,514
Total Land	Ac.	26.723	26.723	26.723	26.723	26.723	26.723
Total Land Used	Ac.	22.555	24.088	26.723	26.723	26.723	26.723
Developed Land	Ac.	4.711	4.711	4.711	4.711	UL[a]	UL
Developed Land Used	Ac.	4.597	3.165	4.711	4.711	8.650	9.608
MVP of Developed Land	Rs.	--	--	491	347	--	--
Paddy Localization	Ac.	--	5.862	--	5.862	--	5.862
Paddy Localization Used	Ac.	NA[b]	--	NA	2.020	NA	5.862
MVP of Paddy Localization	Rs.	--	--	--	--	360	307
Kharif Localization	Ac.	5.387	2.691	5.387	2.691	5.387	2.691
Kharif Localization Used	Ac.	2.485	2.110	4.711	2.691	5.387	2.691
MVP of *Kharif* Localization	Rs.	--	--	--	--	174	178
Rabi Localization	Ac.	4.224	2.110	4.224	2.110	4.224	2.110
Rabi Localization Used	Ac.	2.485	2.110	4.224	2.110	4.224	2.110
MVP of *Rabi* Localization	Rs.	--	40.86	--	122	285	270
Cotton Localization	Ac.	2.112	1.055	2.112	1.055	2.112	1.055
Cotton Localization Used	Ac.	2.112	1.055	.487	1.055	2.112	1.055
MVP of Cotton Localization	Rs.	--	40.86	--	122	324	317

TABLE IV-4 (continued)

Item	Unit	Model 1		Model 2		Model 3	
		Farm 3	Farm 3P	Farm 3	Farm 3P	Farm 3	Farm 3P
Credit Available	Rs.	2,330	2,330	UL	UL	UL	UL
Credit Used	Rs.	2,330	2,330	5,438	5,048	5,648	6,260
MVP of Credit	Rs.	1.80	1.65	--	--	--	--
Crops							
Paddy	Ac.	--	--	--	1.546	--	5.862
Irrigated Cotton	Ac.	4.597	3.165	--	--	2.112	1.055
Dryland Cotton	Ac.	17.958	21.923	--	--	--	--
Dryland _Jowar_	Ac.	--	--	22.012	22.012	18.073	17.115
Irrigated _Kharif_ _Bajra_ and Irrigated _Rabi_ Wheat	Ac.	--	--	4.711	3.165	3.073	2.110
Irrigated _Kharif_ _Jowar_	Ac.	--	--	--	--	2.314	.001
Irrigated _Rabi_ Wheat	Ac.	--	--	--	--	1.151	--
Irrigated _Kharif_ _Bajra_ and Dry _Jowar_	Ac.	--	--	--	--	--	.580

[a] UL means unlimited.

[b] NA means not applicable.

is based on trading cotton for rabi localization and using rabi localization for double cropping.

In Model 3 Farmers 3 and 3P use all of their localizations. There is no trading of localizations which means cotton and paddy localizations are used for growing cotton and paddy. As shown in Table IV-4 both farmers grow a variety of crops. Farmer 3's highest MVP is for paddy localization while 3P's is for cotton localization.

Profitable Crops on Farms 4 and 4P

The results for Farmers 4 and 4P are presented in Table IV-5. Farmer 4 grows dryland cotton and safflower and 9.296 acres of irrigated cotton. It is noticed that Farmer 4 has .278 acres of total land that are not used. Since capital is limiting in this model, the net income per rupee invested, as shown in Table IV-1, page 83, would lead us to expect the farmer to use all of his total land for dry crops before moving to the irrigated crops. We cannot say for sure why Farmer 4 does not use all of his total land. However, Farmer 4 is hiring considerable amounts of labor and the data in Table IV-1 are based on use of family labor which is "free". Perhaps this explains this phenomena, especially since Farmer 1 is already growing 27.302 acres of dryland cotton. By switching to irrigated crops which have different monthly labor requirements than dryland cotton, he probably profits by spending less on hired labor. Nevertheless, the results of Model 1 for Farmer 4 shows that irrigated crops may be competitive with dryland crops even in limited capital situations.

TABLE IV-5

SELECTED RESULTS OF THREE MODELS FOR FARM 4 AND FARM 4P UNDER LOCALIZATION SITUATION I

Item	Unit	Model 1		Model 2		Model 3	
		Farm 4	Farm 4P	Farm 4	Farm 4P	Farm 4	Farm 4P
Net Income	Rs.	13,049	12,512	15,167	15,914	15,167	15,921
Total Land	Ac.	39.262	39.262	39.262	39.262	39.262	39.262
Total Land Used	Ac.	38.984	39.262	39.262	39.262	39.262	39.262
Developed Land	Ac.	14.540	14.540	14.540	14.540	UL[a]	UL
Developed Land Used	Ac.	9.296	7.156	13.512	14.540	13.512	15.177
MVP of Developed Land	Rs.	--	--	--	11.11	--	--
Paddy Localization	Ac.	--	8.599	--	8.599	--	8.599
Paddy Localization Used	Ac.	NA[b]	2.512	NA	8.599	NA	8.599
MVP of Paddy Localization	Rs.	--	--	348	313	348	328
<u>Kharif</u> Localization	Ac.	7.903	3.947	7.903	3.947	7.903	3.947
<u>Kharif</u> Localization Used	Ac.	6.197	3.096	7.903	3.947	7.903	3.947
MVP of <u>Kharif</u> Localization	Rs.	--	--	189	208	189	197
<u>Rabi</u> Localization	Ac.	6.197	3.096	6.197	3.096	6.197	3.096
<u>Rabi</u> Localization Used	Ac.	6.197	3.096	6.197	3.096	6.197	3.096
MVP of <u>Rabi</u> Localization	Rs.	93.10	144.12	289	286	289	295
Cotton Localization	Ac.	3.099	1.548	3.099	1.548	3.099	1.548
Cotton Localization Used	Ac.	3.099	1.548	3.099	1.548	3.099	1.548
MVP of Cotton Localization	Rs.	93.1	144.12	332	318	332	331

TABLE IV-5 (continued)

Item	Unit	Model 1		Model 2		Model 3	
		Farm 4	Farm 4P	Farm 4	Farm 4P	Farm 4	Farm 4P
Credit Available	Rs.	4,000	4,000	UL	UL	UL	UL
Credit Used	Rs.	4,000	4,000	7,613	8,660	7,613	8,654
MVP of Credit	Rs.	1.18	0.97	--	--	--	--
Crops							
Paddy	Ac.	--	2.512	--	8.599	--	8.599
Irrigated Cotton	Ac.	9.296	4.644	3.099	1.548	3.099	1.548
Dryland Cotton	Ac.	27.302	24.272	--	--	--	--
Dryland Jowar	Ac.	--	3.816	25.750	24.722	25.750	24.085
Dryland Safflower	Ac.	2.386	4.018	--	--	--	--
Irrigated Kharif Bajra and Irrigated Rabi Wheat	Ac.	--	--	3.687	2.650	3.687	2.013
Irrigated Kharif Jowar	Ac.	--	--	4.216	--	4.216	--
Irrigated Rabi Wheat	Ac.	--	--	2.510	.446	2.510	1.083
Irrigated Kharif Bajra and Dry Jowar	Ac.	--	--	--	1.297	--	1.934

[a]UL means unlimited.

[b]NA means not applicable.

Farmer 4P, in Model 1, grows a variety of crops including dryland cotton, safflower, and *jowar*. He grows paddy and irrigated cotton and exhausts his *rabi* and cotton localizations. He combines *rabi* localization with *kharif* and trades for cotton land.

In Model 2 and Model 3 the results are the same for Farmer 4 and almost the same for Farmer 4P. This is because the farmers actually have enough developed land that allowing unlimited developed land in Model 3 does not affect them very much. Farmer 4 has 1.028 acres of surplus developed land in Model 2. In Models 2 and 3 both farmers grow a variety of crops.

II. CROP PROFITABILITY UNDER LOCALIZATION SITUATION II

Profitable Crops on Farms 1 and 1P

The models used under Localization Situation II are exactly the same as Models 1, 2, and 3 used in Localization Situation I. The only difference in the models used in Localization Situation I and Localization Situation II is the different localization assignments between the two situations.

The results for Farmers 1 and 1P are given in Table IV-6. In Model 1 both farmers grow 9.266 acres of dryland cotton. This is the same thing they did in Model 1, Localization Situation I, which is discussed on pages 82 through 86. In Model 2 they again do the same thing as in Model 2, Localization Situation I, which is discussed on page 86.

In Model 3, Farmer 4 uses all his *kharif* and *rabi* localizations in combination for growing irrigated *kharif jowar* followed by irrigated

TABLE IV-6

SELECTED RESULTS OF THREE MODELS FOR FARM 1 AND FARM 1P UNDER LOCALIZATION SITUATION II

Item	Unit	Model 1		Model 2		Model 3	
		Farm 1	Farm 1P	Farm 1	Farm 1P	Farm 1	Farm 1P
Net Income	Rs.	2,217	2,217	3,046	3,046	4,841	4,935
Total Land	Ac.	11.849	11.849	11.849	11.849	11.849	11.849
Total Land Used	Ac.	9.266	9.266	11.849	11.849	11.489	11.849
Developed Land	Ac.	--	--	--	--	UL[a]	UL
Developed Land Used	Ac.	NA[b]	NA	NA	NA	2.532	3.832
MVP of Developed Land	Rs.	--	--	709	709	--	--
Paddy Localization	Ac.	--	2.599	--	2.599	--	2.599
Paddy Localization Used	Ac.	NA	--	NA	--	NA	2.599
MVP of Paddy Localization	Rs.	--	--	--	--	391	391
Kharif Localization	Ac.	2.532	1.233	2.532	1.233	2.532	1.233
Kharif Localization Used	Ac.	--	--	--	--	2.532	1.233
MVP of Kharif Localization	Rs.	--	--	--	--	242	346
Rabi Localization	Ac.	2.532	1.233	2.532	1.233	2.532	1.233
Rabi Localization Used	Ac.	--	--	--	--	2.532	1.233
MVP of Rabi Localization	Rs.	--	--	--	--	467	363
Credit Available	Rs.	631	631	UL	UL	UL	UL
Credit Used	Rs.	631	631	1,300	1,300	2,570	2,540
MVP of Credit	Rs.	3.44	3.44	--	--	--	--

TABLE IV-6 (continued)

Item	Unit	Model 1		Model 2		Model 3	
		Farm 1	Farm 1P	Farm 1	Farm 1P	Farm 1	Farm 1P
Crops Grown							
Paddy	Ac.	--	--	--	--	--	2.599
Dryland Cotton	Ac.	9.266	9.266	--	--	--	--
Dryland Jowar	Ac.	--	--	11.849	11.849	9.317	8.017
Irrigated Kharif Jowar and Irrigated Rabi Wheat	Ac.	--	--	--	--	2.532	1.233

[a]UL means unlimited.

[b]NA means not applicable.

rabi wheat. Farmer 1P uses all of his kharif and rabi localizations in this same manner and uses his paddy localization for paddy. Both farmers grow dryland jowar.

Profitable Crops on Farms 2 and 2P

The results on Farms 2 and 2P are presented in Table IV-7. Both farmers grew .885 acres of irrigated safflower and the rest of the land was in dryland cotton. The MVP of credit is Rs. 2.51. None of the localizations are exhausted and developed land is in surplus.

In Model 2, Farmer 2 grows double cropped jowar and wheat to the extent of his developed land. Farmer 2P grows this same double crop to the extent of his kharif and rabi localization and uses the balance of his developed land for paddy. The MVP's for developed land are Rs. 784 for Farm 2 and Rs. 426 for Farm 2P. This difference appears to occur because Farmer 2P has exhausted all of his rabi localization and could not use more developed land for double cropping. Farmer 2 has surplus rabi localization and could use more developed land for double cropping.

In Model 3 all kharif and rabi land is used for double cropping of jowar and wheat. All paddy localization is used for paddy and dryland jowar is grown on drylands.

Profitable Crops on Farms 3 and 3P

Results for Farms 3 and 3P are presented in Table IV-8. In Model 1, Farmer 3 grows only dryland and irrigated cotton. He does not exhaust all of his total land or developed land. In this limited capital situation irrigated cotton competes favorably with dryland cotton,

TABLE IV-7

SELECTED RESULTS OF THREE MODELS FOR FARM 2 AND FARM 2P UNDER LOCALIZATION SITUATION II

Item	Unit	Model 1		Model 2		Model 3	
		Farm 2	Farm 2P	Farm 2	Farm 2P	Farm 2	Farm 2P
Net Income	Rs.	3,775	3,775	5,457	5,277	6,285	6,396
Total Land	Ac.	14.244	14.244	14.244	14.244	14.244	14.244
Total Land Used	Ac.	14.244	14.244	14.244	14.244	14.244	14.244
Developed Land	Ac.	1.983	1.983	1.983	1.983	UL[a]	UL
Developed Land Used	Ac.	.885	.885	1.983	1.983	3.044	4.606
MVP of Developed Land	Rs.	--	--	784	426	--	--
Paddy Localization	Ac.	--	3.124	--	3.124	--	3.124
Paddy Localization	Ac.	NA	--	NA	.501	NA	3.124
MVP of Paddy Localization	Rs.	--	--	--	--	444	426
Kharif Localization	Ac.	3.044	1.482	3.044	1.482	3.044	1.482
Kharif Localization Used	Ac.	--	--	1.983	1.482	3.044	1.482
MVP of Kharif Localization	Rs.	--	--	--	--	352	400
Rabi Localization	Ac.	3.044	1.482	3.044	1.482	3.044	1.482
Rabi Localization Used	Ac.	.885	.885	1.983	1.482	3.044	1.482
MVP of Rabi Localization	Rs.	--	--	--	357.7	392	384
Credit Available	Rs.	1,083	1,083	UL	UL	UL	UL
Credit Used	Rs.	1,083	1,083	2,536	2,405	3,071	3,031
MVP of Credit	Rs.	2.51	2.51	--	--	--	--

TABLE IV-7 (continued)

Item	Unit	Model 1		Model 2		Model 3	
		Farm 2	Farm 2P	Farm 2	Farm 2P	Farm 2	Farm 2P
Crops Grown							
Paddy	Ac.	--	--	--	.501	--	3.124
Irrigated Rabi Safflower	Ac.	.885	.885	--	--	--	--
Dryland Cotton	Ac.	13.359	13.359	--	--	--	--
Dryland Jowar	Ac.	--	--	12.261	12.261	11.200	9.638
Irrigated Kharif Jowar and Irrigated Rabi Wheat	Ac.	--	--	1.983	1.482	3.044	1.482

[a]UL means unlimited.

[b]NA means not applicable.

TABLE IV-8

SELECTED RESULTS OF THREE MODELS FOR FARM 3 AND FARM 3P UNDER LOCALIZATION SITUATION II

Item	Unit	Model 1		Model 2		Model 3	
		Farm 3	Farm 3P	Farm 3	Farm 3P	Farm 3	Farm 3P
Net Income	Rs.	7,474	7,426	10,119	9,631	10,762	10,885
Total Land	Ac.	26.723	26.723	26.723	26.723	26.723	26.723
Total Land Used	Ac.	23.961	24.935	26.723	26.723	26.723	26.723
Developed Land	Ac.	4.711	4.711	4.711	4.711	UL[a]	UL
Developed Land Used	Ac.	4.032	3.305	4.711	4.711	5.711	8.642
MVP of Developed Land	Rs.	--	--	643	341	--	--
Paddy Localization	Ac.	--	5.862	--	5.862	--	5.862
Paddy Localization Used	Ac.	NA[b]	.525	NA	1.931	NA	5.862
MVP of Paddy Localization	Rs.	--	--	--	--	390	290
Kharif Localization	Ac.	5.711	2.780	5.711	2.780	5.711	2.780
Kharif Localization Used	Ac.	--	--	4.711	2.780	5.711	2.780
MVP of Kharif Localization	Rs.	--	--	--	--	230	204
Rabi Localization	Ac.	5.711	2.780	5.711	2.780	5.711	2.780
Rabi Localization Used	Ac.	4.032	2.780	4.711	2.780	5.711	2.780
MVP of Rabi Localization	Rs.	--	79.78	--	300	412	406
Credit Available	Rs.	2,330	2,330	UL	UL	UL	UL
Credit Used	Rs.	2,330	2,300	5,847	5,178	6,462	6,455
MVP of Credit	Rs.	1.80	1.52	--	--	--	--

TABLE IV-8 (continued)

Item	Unit	Model 1		Model 2		Model 3	
		Farm 3	Farm 3P	Farm 3	Farm 3P	Farm 3	Farm 3P
Crops Grown							
Paddy	Ac.	--	.525	--	1.931	--	5.862
Irrigated Cotton	Ac.	4.032	2.780	--	--	--	--
Dryland Cotton	Ac.	19.929	21.630	--	--	--	--
Dryland Jowar	Ac.	--	--	22.012	22.012	21.012	18.081
Irrigated Kharif Jowar and Irrigated Rabi Wheat	Ac.	--	--	4.711	2.780	5.711	2.780

[a]UL means unlimited.

[b]NA means not applicable.

otherwise the entire acreage would have been utilized. Farmer 3P grows irrigated cotton to the extent of his rabi localization. He grows paddy which indicates, since total land was not exhausted, that paddy can compete with dryland cotton in this limited capital situation.

In Models 2 and 3, both Farmer 3 and 3P use kharif and rabi localizations in combination for double cropping. All paddy localization is used for paddy.

Profitable Crops on Farms 4 and 4P

Results for Farmers 4 and 4P are presented in Table IV-9. In Model 1, Farmer 4 double crops only .771 acres. He grows 7.608 acres of irrigated cotton, .698 acres of dryland safflower and the balance of the farm is in dryland cotton. The MVP of credit is Rs. 0.84 which is considerably less than for Farmers 1, 2, and 3 in Model 1. However, an MVP of Rs. 0.84 indicates that additional use of credit would be very profitable.

Farmer 4P in Model 1 exhausts his rabi localization by growing irrigated cotton. He does not use all of his paddy localization. An additional acre of rabi localization which would probably be used for cotton would increase his net income by Rs. 162.61. Cotton, safflower, and jowar are grown on drylands.

In Models 2 and 3, Farmer 4's results are the same. This is because he already has surplus developed land in Model 2 which makes both models unlimited capital and unlimited developed land models. In these models Farmer 4 uses all localizations for double cropping of jowar and wheat and all dryland for jowar.

TABLE IV-9

SELECTED RESULTS OF THREE MODELS FOR FARM 4 AND FARM 4P UNDER LOCALIZATION SITUATION II

Item	Unit	Model 1		Model 2		Model 3	
		Farm 4	Farm 4P	Farm 4	Farm 4P	Farm 4	Farm 4P
Net Income	Rs.	13,192	12,532	16,496	16,460	16,496	16,460
Total Land	Ac.	39.262	39.262	39.262	39.262	39.262	39.262
Total Land Used	Ac.	39.262	39.262	39.262	39.262	39.262	39.262
Developed Land	Ac.	14.540	14.540	14.540	14.540	UL[a]	UL
Developed Land Used	Ac.	8.379	6.999	8.379	12.678	8.379	12.678
MVP of Developed Land	Rs.	--	--	--	--	--	--
Paddy Localization	Ac.	--	8.599	--	8.599	--	8.599
Paddy Localization Used	Ac.	NA[b]	2.920	NA	8.599	NA	8.599
MVP of Paddy Localization	Rs.	61.84	--	423	293	423	293
<u>Kharif</u> Localization	Ac.	8.379	4.079	8.379	4.079	8.379	4.079
<u>Kharif</u> Localization Used	Ac.	.771	--	8.379	4.079	8.379	4.079
MVP of <u>Kharif</u> Localization	Rs.	--	--	237.6	293	237.6	293
<u>Rabi</u> Localization	Ac.	8.379	4.079	8,379	4.079	8.379	4.079
<u>Rabi</u> Localization Used	Ac.	8.379	4.079	8.379	4.079	8.379	4.079
MVP of <u>Rabi</u> Localization	Rs.	192.09	162.61	455	366	455	366
Credit Available	Rs.	4,000	4,000	UL	UL	UL	UL
Credit Used	Rs.	4,000	4,000	8,791	8.969	8,791	8.969
MVP of Credit	Rs.	.84	.84	--	--	--	--

TABLE IV-9 (continued)

Item	Unit	Model 1		Model 2		Model 3	
		Farm 4	Farm 4P	Farm 4	Farm 4P	Farm 4	Farm 4P
Crops Grown							
Paddy	Ac.	--	2.920	--	8.599	--	8.599
Irrigated Cotton	Ac.	7.608	4.079	--	--	--	--
Dryland Cotton	Ac.	30.185	25.446	--	--	--	--
Dryland Jowar	Ac.	--	4.889	30.883	26.584	30.883	26.584
Dryland Safflower	Ac.	.698	1.928	--	--	--	--
Irrigated Kharif Jowar and Irrigated Rabi Wheat	Ac.	.771	--	8.379	4.079	8.379	4.079

[a]UL means unlimited.

[b]NA means not applicable.

The results for Farmer 4P are the same in Models 2 and 3. All *kharif* and *rabi* localizations are used for double cropping and all paddy localization is used for paddy. Dry *jowar* is the only dryland crop grown.

III. CONCLUSIONS AND IMPLICATIONS OF THE THE MICROECONOMIC ANALYSIS

Crops That Were Not Grown

The crops that were grown in Localization Situation I or Localization Situation II are summarized in Table IV-10. Crops that were not grown in any of the models are dryland wheat, irrigated *rabi jowar*, and irrigated *navane* in either *kharif* or *rabi* season. The fact that these crops were not grown does not mean that they are not profitable crops. It does mean, however, that they are not as profitable in the representative farm situations considered as the crops that were grown. Since the representative farms, the models, and the localization situations used do not include all possible farm situations found on the distributary, it is possible that these crops will be grown to some extent in the TBP.

Table IV-1, page 83, shows that dryland wheat does not compare favorably with the other dryland crops by any measure. It has the lowest net income per acre, the highest cash expenses per acre, and the lowest net income per rupee invested of all the dryland crops. *Navane* has the lowest net income per acre and the lowest net income per rupee invested of the irrigated crops. Irrigated *rabi jowar* is third in net returns of the irrigated *rabi* season crops ranking below cotton and wheat. It is

TABLE IV-10

SUMMARY OF CROPS GROWN BY THE REPRESENTATIVE FARMS IN MODEL 1, MODEL 2, AND MODEL 3, UNDER LOCALIZATION SITUATION I AND LOCALIZATION SITUATION II

	Model 1 Farms								Model 2 Farms								Model 3 Farms							
	1	1P	2	2P	3	3P	4	4P	1	1P	2	2P	3	3P	4	4P	1	1P	2	2P	3	3P	4	4P
Localization Situation I																								
Dryland cotton	X[a]	X	X	X	X	X	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dryland jowar	--	--	--	--	--	--	--	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dryland safflower	--	--	--	--	--	--	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Paddy	NA[b]	--	NA	--	NA	--	NA	X	NA	--	NA	X	NA	X	NA	X	NA	X	NA	X	NA	X	NA	X
Irrigated kharif jowar	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	X	X	--
Irrigated cotton	--	--	X	X	X	X	X	X	--	--	--	--	--	--	X	X	X	X	X	X	X	X	X	X
Irrigated rabi wheat	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	X	--	--	X	--	X	--	X	X
Irrigated rabi safflower	--	--	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Irrigated kharif bajra and dryland jowar	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	X	X	X	X	--	X	--	X
Irrigated kharif bajra and irrigated rabi wheat	--	--	--	--	--	--	--	--	--	--	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Localization Situation II																								
Dryland cotton	X	X	X	X	X	X	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dryland jowar	--	--	--	--	--	--	--	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dryland safflower	--	--	--	--	--	--	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Paddy	NA	--	NA	--	NA	X	NA	X	NA	--	NA	X	NA	X	NA	X	NA	X	NA	X	NA	X	NA	X
Irrigatedccotton	--	--	--	--	X	X	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Irrigated rabi safflower	--	--	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Irrigated kharif jowar and irrigated rabi wheat	--	--	--	--	--	--	X	--	--	--	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[a]X denotes crops grown.

[b]NA means not applicable.

third in net returns per rupee invested of the rabi season irrigated crops ranking below safflower and cotton but ahead of wheat. Although irrigated rabi jowar was not grown in the models, it is very likely to be grown to a limited extent by some farmers because it compares favorably with other rabi season crops.

Conclusions from Model 1

Several general conclusions can be drawn from the farm level analysis of crops and from the total results shown in Table IV-10. In Model 1 where capital is limited, we can conclude that farmers prefer to grow crops that have high net returns per rupee invested. Since dryland crops tend to have relatively high returns per rupee invested, they compare favorably with the irrigated crops in Model 1. Table IV-10 shows that the choice of crops in Model 1 does not change significantly in moving from Localization Situation I to Localization Situation II.

In Model 1 where credit was limited, several farmers did not use all of their developed land. The MVP's for developed land were zero for all farms in Model 1. This may explain why many farmers have not developed their lands and may explain why other farmers have very little developed land. Model 1 indicates that where operating capital is scarce and dryland is plentiful, farmers are generally better off to use the credit for inputs for the dryland crops.

It is likely that some farmers in the TBP area either cannot or will not borrow enough money to justify moving to irrigated cropping. Since they have small amounts of input capital relative to their land

and are resistant to borrowing more capital, they are maximizing income by growing dryland crops.

Several officials have attributed the slow development of lands to the fact that farms are "large". If capital is limited or if farmers are unwilling to use credit productively, then this statement may very well be true.

One limitation of this study is that data were not available to allow the including of irrigated crops at low cash input levels. If such data were available, one could determine the value of irrigation water on the "traditional" dryland crops grown at low input levels. A general hypothesis of irrigated farming is that it is most profitable to use "high" levels of inputs on irrigated crops to take maximum advantage of the limited developed land and water. It would be interesting to know the effects of irrigation on traditional crops at low input levels. If the effects are not very beneficial, then this would offer further evidence as to why farmers with limited capital are not developing lands.

<u>Conclusions from Model 2</u>

A review of Model 2 in which credit is unlimited, shows that farmers in both localization situations tend to grow the crops that have the highest net returns per acre, irrespective of the net returns per rupee invested. Dryland <u>jowar</u> has the highest net returns of the dryland crops and is the only dryland crop grown in Model 2. Farms in Model 2, in which developed land was limiting, except to Farmers 4 and 4P, tended to grow double irrigated crops on their developed land to the extent that their <u>kharif</u> and <u>rabi</u> lands in combination would allow them.

Double irrigated crops yield higher returns per acre of developed land than any single crop, including paddy.

In the cases of Farmers 4 and 4P in Model 2, where ample developed land was available, the farmers tended to grow paddy on paddy lands and cotton on cotton lands. This means that it was not profitable to trade paddy for kharif, trade cotton for rabi, or combine them and grow double light irrigated crops. Surplus kharif localization was used for growing irrigated kharif jowar or for growing irrigated kharif bajra followed by dryland jowar.

The primary differences between crops grown in the two localization situations, in Model 1 and in Model 2, are due to the farmer's ownership of equal kharif and rabi localizations and the allowing of four month kharif crops to be double cropped in Localization Situation II. The ownership of equal kharif and rabi localizations in Localization Situation II, means they are combined and used for double cropping. In Localization Situation I, however, since kharif and rabi localizations are not equal, a larger variety of crops is grown. Irrigated bajra, a 90 day crop, is the only kharif crop allowed to be used in double cropping in Localization Situation I. It is replaced by irrigated kharif jowar in Localization Situation II.

Conclusions from Model 3

Model 3, the unlimited developed land and unlimited capital model, shows what is likely to happen when the distributary is fully developed. Although land development in the TBP has been slower than officials would like, there is reason to believe that enough land will eventually be developed to utilize all irrigation water. The shortages of water that have been reported indicate that this much land may already be developed on many distributaries.

The term "fully" developed, as used in the TBP area, originally meant development of all localized lands. Results of Model 3 show that with double cropping becoming popular, there is no need for "fully" developing the distributary. The term, "fully" developed, is more meaningful in referring 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.

It is difficult to predict how much land will eventually be developed. The amount ultimately developed depends to a great extent on the localization regulations that are adopted. A fully double cropped system will require less developed land than a system with less double cropping.

In Model 3 all farmers tend to grow the crops with the highest net returns per acre. A comparison of Model 2 and Model 3 in Localization Situation I, as shown in Table IV-10, page 109, shows that, except for Farmers 4 and 4P, a much larger variety of crops is grown in Model 3. This indicates that plentiful developed land gives farmers more opportunity to utilize their respective localizations to maximum advantage.

<u>Implications for Paddy Cultivation</u>

General observation in the Fortieth Distributary and interviews with farmers and agricultural officials clearly indicate that paddy is the most popular irrigated crop. The results of this investigation, however, do not generally show paddy to be the most popular crop. Although paddy was grown in many situations it certainly was not the most common irrigated crop in the majority of situations.

The main explanation offered for this difference between actual practice and results of this study is the lack of strict enforcement of localization regulations in the present situation. Paddy is shown to have the highest net returns of any single crop. However, under strict localization enforcement paddy is not allowed to be double cropped in any fashion. That is, paddy cannot be followed with another crop of paddy or with another crop of light irrigated crop. In practice, however, farmers are double cropping <u>kharif</u> paddy followed by a summer crop of paddy. They also are following <u>kharif</u> paddy with light irrigated crops of wheat and safflower. The double cropping systems using paddy have higher net returns per acre of developed land used than any double cropping combination of light irrigated crops. Since water is virtually free to the individual farmer, he is not concerned with the fact that paddy requires much more water per acre than the other crops.

If the localizations were strictly enforced, the results show that paddy would still be grown on all paddy localized lands, if developed land and capital were not constraints as in Model 3. The results in Model 2, where capital is unlimited, but developed land is limited to Farmers 2P and 3P, show that paddy is grown only after growing all the double light irrigated crops the localizations would allow. This indicates that paddy is not generally competitive with the double cropped light irrigated crops but is more profitable than any single irrigated crop.

The fact that paddy is readily acceptable for barter, is a preferred staple in the farmer's diet, and is a familiar irrigated crop may lead farmers to show a preference for paddy cultivation greater than was indicated in this study. In comprising the crop budgets only the discernible quantitative characteristics were considered. There may be factors influencing farmers' choice of crops that were not readily discernible.

CHAPTER V

ANALYSIS OF AGGREGATE RESULTS

The primary purposes of the aggregate analysis are: (1) to show what total production is likely to be if various sets of localization regulations are strictly enforced, and (2) to provide data for comparing and evaluating various localization alternatives. Although this analysis is based on the Fortieth Distributary, the results may be applicable to all distributaries in the black soil area.

The primary usefulness of the aggregate analysis is expected to be for comparing results of the various localization alternatives. Thus, the main interest is in what aggregate production will be when the distributary is fully developed. For this reason, the results are reported for all six localization situations under the conditions of Model 3. That is, unlimited developed land and capital are assumed to be available. Aggregate results for Model 2 are also reported for Localization Situations I and II, the situations most comparable to proposed localizations, simply to show likely results under the present situation where developed land is limited but credit is assumed to be unlimited. All aggregate results reported were derived by aggregating the linear programming results on the representative farms.

I. AGGREGATE RESULTS OF MODEL 2

The aggregate results of Model 2 show what production on the Fortieth Distributary is likely to be if the respective localization regulations were strictly enforced, credit were unlimited, and developed land were available in amounts presently developed. The results were obtained by aggregating for the representative farms. The aggregation coefficients used are shown in Table III-7, page 57.

The results for Model 2, Localization Situations I and II, are presented in Table V-1. These results show that the gross value of production (GVP) for Localization Situation II is greater than for Localization Situation I by Rs. 1,455,082. The cash inputs required are greater by Rs. 379,350 and the gross value of production after cash inputs are paid is greater in Localization Situation II by Rs. 1,075,732.

A summary of land utilization for all localization situations considered in the aggregate analysis is presented in Table V-2. It can be seen that more total acres of crop were grown and more acres were double cropped in Localization Situation II (Model 2) than in Localization Situation I (Model 2). However, fewer acres of developed land were required in Localization Situation II.

II. AGGREGATE RESULTS OF MODEL 3

Production and Inputs Required

The aggregate results in Model 3 for Localization Situations I and II are presented in Table V-3. Model 3 shows the production that is likely to occur when the distributary is fully developed, that is, when developed land is not a constraint. The results show that the GVP for Localization Situation II is greater than for Localization Situation I by Rs. 1,844,611. The cash inputs required are greater by Rs. 576,639

TABLE V-1

AGGREGATE ACRES GROWN, VALUE OF CASH INPUTS, GROSS VALUE OF PRODUCTION, AND GROSS VALUE OF PRODUCTION IN EXCESS OF CASH INPUTS ON THE FORTIETH DISTRIBUTARY IN MODEL 2 UNDER LOCALIZATION SITUATIONS I AND II

Crops	Acres Grown	Value of Cash Inputs Required	Gross Value of Production	Gross Value of Production in Excess of Cash Inputs
		Rupees		
Localization Situation I				
Paddy	318	111,236	364,110	252,874
Irrigated Cotton	881	221,307	867,785	646,478
Irrigated Kharif Bajra	3,751	831,221	2,104,311	1,273,090
Irrigated Rabi Wheat	4,403	1,474,564	4,411,806	2,937,242
Irrigated Kharif Jowar	1,137	315,290	949,395	634,105
Dryland Jowar	24,800	2,747,840	10,354,000	7,606,160
Total	35,290	5,701,458	19,051,407	13,349,949
Localization Situation II				
Paddy	342	119,631	391,590	271,959
Irrigated Kharif Jowar	4,996	1,385,390	4,171,660	2,786,270
Irrigated Rabi Wheat	4,996	1,673,160	5,005,992	3,332,832
Dry Jowar	26,197	2,902,627	10,937,247	8,034,620
Total	36,531	6,080,808	20,506,489	14,425,681

TABLE V-2

TOTAL LAND UTILIZATION FOR ALL LOCALIZATION SITUATIONS CONSIDERED IN THE AGGREGATE ANALYSIS

Localization Situation	Total Acres of Crop Grown	Total Acres of Irrigated Crop Grown	Total Acres of Land Used	Total Acres of Developed Land Used	Total Acres Double Cropped
I (Model 2)	35,290	10,490	31,539	6,777	3,751
II (Model 2)	36,531	10,334	31,535	5,338	4,996
I (Model 3)	35,761	13,821	31,534	10,201	4,227
II (Model 3)	37,937	13,475	31,538	7,076	6,399
Paddy Only	31,539	3,237	31,539	3,237	0
I Light Only	36,760	15,825	31.532	11,099	5,228
II Light Only	39,208	15,336	31,540	7,668	7,668
Summer Light Irrigation	33,698	6,918	31,540	4,760	2,158

TABLE V-3

AGGREGATE ACRES GROWN, VALUE OF CASH INPUTS, GROSS VALUE OF PRODUCTION, AND GROSS VALUE OF PRODUCTION IN EXCESS OF CASH INPUTS ON THE FORTIETH DISTRIBUTARY IN MODEL 3 UNDER LOCALIZATION SITUATIONS I AND II

Crops	Acres Grown	Value of Cash Inputs Required	Gross Value of Production	Gross Value of Production in Excess of Cash Inputs
		Rupees		
Localization Situation I				
Paddy	677	236,814	775,165	538,351
Irrigated Cotton	2,370	595,344	2,334,450	1,739,106
Irrigated Kharif Bajra	4,227	936,703	2,371,347	1,434,644
Irrigated Rabi Wheat	4,735	1,585,751	4,744,470	3,158,719
Irrigated Kharif Jowar	1,812	502,467	1,513,020	1,010,553
Dryland Jowar	21,940	2,430,952	9,159,950	6,728,998
Total	35,761	6,288,031	20,898,402	14,610,371
Localization Situation II				
Paddy	677	236,814	775,165	538,351
Irrigated Kharif Jowar	6,399	1,774,442	5,343,165	3,568,723
Irrigated Rabi Wheat	6,399	2,143,025	6,411,798	4,268,773
Dryland Jowar	24,462	2,710,389	10,212,885	7,502,496
Total	37,937	6,864,670	22,743,013	15,878,343

and the gross value of production after cash inputs are paid is greater in Localization Situation II by Rs. 1,267,972.

Table V-2 shows that in Model 3 more total acres of crop were grown and more acres were double cropped in Localization Situation II than in Localization Situation I. However, fewer acres of developed land were required in Localization Situation II.

<u>Analysis of Labor</u>

An analysis of labor required and available is presented for Model 3 because production is greater in Model 3 than in Model 2 and Model 3 requires more labor than Model 2. The analysis is limited to those months of peak labor requirement. Since there is no reason to believe that labor available varies between months, then if peak monthly labor requirements are met the requirements in other months will be met.

In Localization Situation I, August and September were the peak months of labor usage. In August Farmer 4 hired 587 hours, Farmer 4P hired 1080 hours, and Farmer 3P hired 567 hours. None of the other farmers hired any labor in August. The aggregate amount of hired labor required by Farmers 3P, 4, and 4P was 207,896 hours in August. The results of the survey showed that permanent servants were available who would supply 202,150 hours per month. Thus, the hired labor requirement for August could almost be met by permanent servants, if they were properly distributed. Surplus family labor from Farms 1, 1P, 2, 2P, and 3 supply an additional 234,539 hours. These results indicate that labor shortages are unlikely in August if labor is distributed properly. A lack of communication or imperfect knowledge of labor needs could result in some shortages even though labor appears to be available in more than ample quantity.

In September, under Localization Situation I, Farmers 3, 3P, 4, and 4P hire 263, 471, 164, and 1027 hours, respectively. Farmers 1, 1P, 2, and 2P hire no labor. The total amount of hired labor needed is 165,946 hours. As shown in the August analysis, 202,150 hours are supplied by permanent servants which more than meets the requirements. Excess family labor on Farms 1, 1P, 2, and 2P supply an additional 176,674 hours in September. The results of the August and September analyses of labor indicate that labor should not be a constraint in Localization Situation I, Model 3.

In Localization Situation II the peak months of labor requirement are March, July, September, and October. However, since much of the work done in March can be postponed to April and May, March is not considered to be a critical month for labor and is not considered in this analysis. There is little scope for shifting labor forward or backward in the other months.

In July Farmers 3, 3P, 4, and 4P hire 130, 427, 392, and 905 hours of labor, respectively. When aggregated this totals 183,679 hours. This requirement is easily met by permanent servants who supply 202,150 hours. An additional 140,840 hours are supplied by Farmers 1, 1P, 2, and 2P.

In September Farmers 3, eP, 4, and 4P hire 212, 513, 513, and 821 hours, respectively. When aggregated this equals 240,498 hours. Since only 202,150 hours are supplied by permanent servants, additional sources of labor are needed. Farmers 1, 1P, 2, and 2P supply 157,570 hours which more than meets the needs.

In October Farmers 3, 3P, 4, and 4P hire 385, 329, 767, and 756 hours, respectively. When aggregated this equals 351,753 hours. Permanent servants supply 202,150 hours which leaves 149,603 hours to be supplied from other sources. Farmers 1, 1P, 2, and 2P supply 140,697 hours which leaves a need of 8,906 hours to be met from other sources. It is very likely that the other sources of labor such as landless labor and migrant labor can supply this amount. However, even though adequate labor is available, the lack of communication between laborers and farmers seeking labor make it likely that some shortages will occur in October. Planners must take this into consideration in evaluating localization alternatives.

A review of computer printouts showed that hired bullock power was not excessive in any month. No serious shortages of bullock power are likely to occur based on these results.

III. AGGREGATE RESULTS IN THE PADDY ONLY AND LIGHT IRRIGATED ONLY LOCALIZATIONS

An aggregate analysis of production when all water is used for paddy, and when all water is used for light irrigation, is presented to show the tradeoffs that occur when paddy localization is increased or decreased. The construction of the Paddy Only Localization is presented on page 59. The construction of the Light Irrigation Only Localization Situations I and II is presented on pages 59 through 64. All of these localizations were programmed under conditions prevailing in Model 3, that is, with unlimited credit and unlimited developed land available.

The results of aggregation for these localization situations are presented in Table V-4. It is readily seen that when all the water is allocated for paddy the GVP is considerably less than when all water is allocated for light irrigation. Table V-2, page 119, shows how land is utilized under these localization situations. A comparison of the results in Table V-4 with the results presented in Table V-3, page 120, for the respective Localization Situation will show the results of using the water allocated for paddy (Table V-3), for light irrigation (Table V-4).

It is obvious from studying these tables that if gross production from a given amount of water is the primary objective in the TBP, then there is little justification for production of paddy. However, if paddy were completely eliminated from the TBP area, then the "local" price of paddy might rise considerably, making it more competitive with other crops.

IV. AGGREGATE RESULTS IN THE SUMMER LIGHT IRRIGATION LOCALIZATION SITUATION

In the Summer Light Irrigation Localization Situation, paddy is the only irrigated crop allowed in kharif season and only light irrigated crops are allowed in the summer. The construction of this localization is described on page 64. The main purpose of this analysis is to show what would likely happen if the localizations were changed on the LBLLC to allow summer light irrigation, as is now allowed on the RBLLC. The RBLLC was changed to summer light irrigation primarily because of the

TABLE V-4

AGGREGATE ACRES GROWN, VALUE OF CASH INPUTS, GROSS VALUE OF PRODUCTION, AND GROSS VALUE OF PRODUCTION IN EXCESS OF CASH INPUTS ON THE FORTIETH DISTRIBUTARY UNDER THE PADDY ONLY LOCALIZATION SITUATION AND THE LIGHT ONLY LOCALIZATION SITUATIONS I AND II

Crops	Acres Grown	Value of Cash Inputs Required	Gross Value of Production	Gross Value of Production in Excess of Cash Inputs
		Rupees		
Paddy Only Localization Situation				
Paddy	3,237	1,132,232	3,706,136	2,573,904
Dry Jowar	28,303	3,135,924	11,816,502	8,680,578
Total	31,539	4,268,156	15,522,638	11,254,482
Light Only Localization Situation I				
Irrigated Cotton	2,370	595,344	2,334,450	1,739,106
Irrigated Kharif Bajra	5,228	1,158,524	2,932,908	1,774,384
Irrigated Kharif Jowar	2,081	577,061	1,737,635	1,160,574
Irrigated Rabi Wheat	6,146	2,058,295	6,158,292	4,099,997
Dryland Jowar	20,935	2,319,598	8,740,362	6,420,764
Total	36,760	6,708,822	21,903,647	15,194,825
Light Only Localization Situation II				
Irrigated Kharif Jowar	7,668	2,126,336	6,402,780	4,276,444
Irrigated Rabi Wheat	7,668	2,568,013	7,683,336	5,115,323
Dryland Jowar	23,872	2,645,017	9,966,560	7,321,543
Total	39,208	7,339,366	24,052,676	16,713,310

difficulty in enforcing regulations where paddy and light irrigated crops were allowed during the same season.

The results of the Summer Light Irrigation Localization are presented in Table V-5. It was assumed that unlimited credit and developed land were available.

A comparison of the results under summer light irrigation, shown in Table V-5, with results in the localization situations shown in Tables V-3 and V-4, pages 120 and 125, shows that, except for the Paddy Only Localization, the GVP is considerably lower under summer irrigation. Land utilization under summer light irrigation is shown in Table V-2, page 119.

The primary disadvantages of the summer light irrigation situation are: (1) irrigated crops grown in the summer require considerably more water than the same crops grown during other seasons, which means fewer irrigated acres can be grown, and (2) the light irrigated crops with the highest returns per acre such as cotton, wheat, and safflower cannot be grown during the summer season.

TABLE V-5

AGGREGATE ACRES GROWN, VALUE OF CASH INPUTS, GROSS VALUE OF PRODUCTION, AND GROSS VALUE OF PRODUCTION IN EXCESS OF CASH INPUTS ON THE FORTIETH DISTRIBUTARY UNDER LOCALIZATION FOR SUMMER LIGHT IRRIGATION

Crops	Acres Grown	Value of Cash Inputs Required	Gross Value of Production	Gross Value of Production in Excess of Cash Inputs
		Rupees		
Paddy	2,158	754,763	2,470,566	1,715,803
Irrigated Summer Jowar	4,760	1,319,948	3,974,600	2,654,652
Dryland Jowar	26,780	2,967,224	11,180,650	8,213,426
Total	33,698	5,041,935	17,625,816	12,583,881

CHAPTER VI

CONCLUSIONS AND IMPLICATIONS

I. POLITICAL CONSIDERATIONS

This study is essentially an economic analysis of crops and irrigation water use in the TBP area. The data used in constructing the general model are economic data and social and political considerations are not taken into account. Thus, the results of this study reflect economic consequences that are likely when various sets of localization regulations are enforced on the representative farms. Although political factors were not considered in constructing the model, except to the extent that they affected the economic data collected, the results of the study certainly have political implications.

TBP administrators are charged with the responsibility of making decisions that lead to maximum overall economic benefits for the TBP area. However, they are subject to many political pressures that may not have the objective of overall economic well being. Thus TBP administrators must consider the political as well as economic implications of actions regarding land use localizations.

Many farmers, especially those in Stratum IV, are likely to suffer economic losses when localization regulations are strictly enforced. Survey data show that Stratum IV farmers comprise 21 percent of the farmers, own 37 percent of the land, and 61 percent of the developed land. If developed land is an indication of water being used, then Stratum IV farmers are using more than their proportionate share. If these farmers had not been receiving adequate amounts of water, then it is unlikely that they would have developed land to the extent they have. General observation on the Fortieth Distributary indicates that most of this developed land is used for paddy and much of it is double cropped. Strict localization enforcement would result in most of these farmers having to give up paddy cultivation completely, and others would have to give up some paddy. These farmers are now enjoying irrigation water for eleven months to use very much as they please.

The water shortages that are now occurring do not appear to be general shortages, but shortages that affect only certain farmers who are unable to aggressively compete for water, or who are in geographical disadvantageous locations for receiving water during peak periods. It is unlikely that many of the farmers in Stratum IV are seriously affected by the present water shortages. Thus, the majority of these farmers are not likely to support localization regulations for the purpose of eliminating water shortage. In fact, it is primarily these farmers who are causing the water shortages. They cultivate 61 percent of the total irrigated land, most of it in paddy.

Farmers in Stratum IV may well be the dominant political force opposed to localization enforcement. If wealth is an indication of political power, then this group may exert much more pressure than their 21 percent of the distributary population would indicate.

Many, if not most of the farmers in Strata II and III, are likely to be better off economically when localizations are enforced. These two groups comprise 63 percent of the farmers, own 54 percent of the land, and 37 percent of the developed land. These farmers should be able to generate considerable political pressure in favor of enforcement of localization if they are convinced they will be better off under enforcement and if they are at all united and willing to exert pressure in favor of localization enforcement. However, this study does not indicate that these farmers are any less opposed to localization enforcement than any other group. The fact that these farmers have considerable lands localized that are not developed indicates their potential gains when localizations are enforced. The shortages of water now occurring could be a deterrent to these farmers in developing more lands. Strict enforcement of localizations would eliminate this deterrent if it does exist.

Farmers in Stratum I have the highest potential gains from localization enforcement of any group. However, to realize this gain they must be willing to develop lands and adopt irrigation which they either will not do because of unknown personal reasons or are unable to do because of their limited capital.

Definite conclusions about which groups are likely to support localization enforcement cannot be drawn from this study. However, the study does indicate reasonably well which groups are likely to benefit or at least obtain potential benefits when localization regulations are enforced. Administrators may use this information in determining which groups to concentrate upon to muster support and which ones are likely to present opposition. If a political majority does not exist or cannot be created which will support and abide by localization regulations, then they have little chance of being effectively enforced. The complex political relationships that generally exist between farmers, PWD inspectors, and tax officials are such that there must be local support for localization regulation enforcement or it is not likely to be successful.

The results of this study may be used by administrators and politicians to convince farmers of the total economic benefits to be gained by enforcing localization regulations. The microeconomic results can be used for selecting those groups of farmers who stand to gain the most by localization enforcement. The gains or losses that a particular farmer is likely to sustain can be roughly approximated by comparing his situation to that of the representative farmers. This study provides a scientific basis that administrators may use to convince farmers to support regulations. Clearly, the most viable potential supporters are those farmers who have localized lands that are not developed or are developed and are suffering water shortages.

Farmers presently seem to view localization enforcement only in terms of "giving up paddy" and not in terms of an "equitable allocation of water." Certainly localization enforcement, except in the Paddy Only Localization Situation, would result in less paddy, but it would also result in an "equitable" distribution of water, even in the Paddy Only Localization Situation. This study clearly shows that economic benefits will be greatest when localization regulations are enforced and paddy is held to a minimum. The basic problems are to determine which farmers will benefit from localization enforcement and how to muster their support.

II. AGRICULTURAL ADJUSTMENT PROBLEMS

Credit

Although the major focus of this study has been on water use, credit has been a very important consideration. Cash on hand and credit available determine the extent to which farmers can purchase productive inputs for the given crop season and also the extent to which land can be developed. The survey results indicate that farmers in Stratum I, II, and III have very little cash on hand. Farmers in Stratum IV have very little cash on hand relative to their total assets. Thus, credit must be supplied in large amounts for operating expenses and for land development. Assumptions about the amount of credit available were made based on present indebtedness of the representative farmers. However, considerably more research is needed into the availability of credit in the TBP area.

Agricultural planners are probably interested in knowing in which model, that is Model 1, 2, or 3, most farmers are likely to be found. Since we know the amount of developed land owned by farmers in the four strata, credit availability is the main determinant. Farmers in Stratum IV certainly have enough land already developed to put most of them in Model 3. If credit is as limited to Stratum IV farmers as it was assumed to be in Model 1, then these farmers may be using fewer cash inputs per acre than they are allowed to use under the crop budgets constructed for this study. However, the relative prosperity of Stratum IV farmers would indicate that adequate credit is generally available to meet their operating needs. Also if substantial operating credit were not available to these farmers then it is unlikely that they would have developed lands to such a great extent.

It is more difficult to generalize about which model farmers in Stratum II and III are likely to be found. Certainly, they are not in Model 3 because they do not have their localized lands fully developed. Some farmers in Stratum II and III are likely to be developing more lands and moving gradually toward Model 3. However, some farmers in both Stratum II and III are very likely to be "locked in" Model 2 because of lack of credit for developing or lack of incentive to develop more land. This lack of incentive could be caused by their belief in impending water shortages, or by numerous other factors peculiar to the specific farmer such as family labor shortages or lack of managerial ability. Also some farmers may be "locked in" Model 1 because of very limited operating capital. If farmers in Stratum II or III are actually in Model 1 then they are probably using inputs at levels lower than are allowed in this study.

Farmers in Stratum I appear to be primarily in Model 1 with regard to credit availability. However, since these farmers have no developed land, the maximum amounts of operating credit they could use is relatively small. The microeconomic results show that these farmers would be no better off with developed lands unless considerable amounts of operating credit became available. Research is needed into the feasibility of "special" programs for those generally "small" farmers who have not developed any lands. If localization regulations are strictly enforced, then the water allocated to these farmers will not be used unless they develop lands. There is a possibility that these farmers simply do not possess the managerial skills to adopt irrigated farming. If further research shows this to be true, then gross value of production is likely to be less when localization regulations are enforced than it would be if water intended for these farmers were reallocated to more "progressive" farmers.

Another possibility, not evidenced by this study, is that Stratum I farmers may be "uncreditworthy" by standards of institutional lending agencies. Survey data show that virtually all credit was from money-lenders and a considerable portion of credit going to these farmers was for consumption rather than for farm expenditures. Research is needed to determine "creditworthiness" of Stratum I farms relative to farmers in the other strata.

The annual interest rate of 80 percent to farms in Stratum I did not prove to be a deterrent to borrowing. Programs were run (although not reported in this study) for all three models for Farmer 1 at 30 percent interest and there was no change in the amount of credit used or in the crops grown. In practice, however, very high interest rates may be a deterrent to borrowing. Nevertheless, this study indicates that perhaps too much attention has been paid to providing government supported low interest rate loans and perhaps more total funds at higher rates would be more desirable. Annual rates of 30 percent or higher do not appear to be excessive in view of the returns to irrigated farming. The amounts of credit used in Model 3 should be viewed as maximums for all farmers because farmers are likely to replace much borrowed capital with cash on hand as they move to Model 3.

The results of this study have implications for credit agencies in the TBP. For example, if localization regulations are enforced the bulk of the remaining land to be developed will be owned by farmers in Stratum I, II, or III. This means the PLDB must necessarily concentrate on making loans to these farmers rather than to farmers in Stratum IV who have been the primary recipients of PLDB loans in the past. Loan programs may have to be adjusted somewhat to accommodate these farmers, especially those in Stratum I. It is likely that the average size of loans will decrease as these farmers take loans because they will have less land to develop. Ooan serving personnel may have to be increased to supervise the development work on these farms as well as to collect the loan payment.

Crop Research Needs

Although paddy is generally the "preferred" crop of most farmers, this study does not indicate a strong "preference" for paddy when localization regulations are enforced. Although paddy has higher returns per acre than any single light irrigated crop, when it is not allowed to be double cropped due to localization enforcement, then it is generally not the "preferred" crop. However, in Model 3 paddy is grown on all lands localized for paddy. In the other models, limited developed land is generally used for light irrigated double cropping rather than for paddy. Several farm adjustments will be made if localization regulations are enforced. The reduction in paddy implies an increase in total irrigated acres as water is shifted from heavy to light irrigation. This may result in managerial problems not considered in the study. Farmers may have severe managerial problems in adopting large scale light irrigation that they have not had with paddy.

There will be a continuing need to update the crop data used in this study. As new crops and new varieties are introduced the data will need revising. There is a definite need for new kharif season, light irrigated crops with durations of four months or less that have net returns as high as the rabi crops of wheat, safflower, and cotton. More profitable kharif season crops would make paddy less profitable relative to the light crops.

Labor Adjustments

It is assumed in this study that laborers are willing to work 250 hours per month. This assumption is based on the fact that laborers now often work this much or more during the "busy" months and have reported that they are available this much throughout the year. However, there are indications that as family income increases the supply of labor may decrease. Several farmers reported proudly that as their incomes increased they had assumed managerial roles and their wives no longer worked in the fields. Data in Table III-1, page 36, show that the ratio of women to men in the family labor force decreases as you move from Farm 2 to Farm 4. These facts indicate that a "backward bending supply curve for labor" may exist. Further research may be needed to see if shortage of labor may become a more serious problem than this study indicates.

III. WATER MANAGEMENT

The present system of water allocation, that is, localization regulations that are not strictly enforced, appears to consist of a jumble of political and social pressures, much argument among farmers and officials, occasional physical force, and some violence between disgruntled farmers. Occasionally, the entire distributary is "dammed" up to increase the flow to certain farmers and a considerable number of locks on the shut off gates have been broken. An orderly system of water allocation, even if all the water were used for paddy, certainly would result in more efficient usage as more lands are developed and water becomes relatively more scarce.

Some system of land use localization appears to be the most feasible means of allocating water for the foreseeable future. Land use localization is a relatively simple system that can be implemented without expensive equipment or highly trained personnel at the field level. There is also scope for eventually changing to a more complex system of land use localizations which would include several "staggered" planting dates for each localization category of paddy, kharif, rabi, and cotton. Also there is scope for selling localizations between farmers at market determined rates to increase efficiency. This way farmers could "trade" with others for the localizations they preferred.

Once one of the relatively simple localization systems considered in this study is implemented, understood, and supported by farmers, then research will be needed to determine the planting dates in a more sophisticated system. Numerous planting dates could result in using the peak flow of water in several months rather than just in two or three peak months as is done in the proposed system. This should allow many more acres to be localized and irrigated. However, before sophisticated localization systems are attempted, farmers need to understand, approve of, and abide by localization regulations.

There is a continuing need for research regarding irrigation water management. The MUAS research stations are presently conducting research on water requirements of crops and salinity problems. The Pilot Project for Soil and Water Management at Bellary is investigating land development practices and water usage of various crops under farm conditions on the Right Bank Canals. There is a need for another Pilot Project located on the LBLLC to conduct similar research to that being done on the Right Bank Canals. This would make research findings more applicable to the specific localization regulations on the LBLLC.

BIBLIOGRAPHY

BIBLIOGRAPHY

"A Brief Note on the Development of Area Under Tungabhadra Project Left Bank Canal in Sindhnur Taluk, Raichur District," Department of Agriculture, Government of Mysore, an unpublished bulletin, 1970.

A Guide for Estimating Irrigation Water Requirements. New Delhi: Department of Agriculture, 1970.

Anagol, Jayakumar. "A Strategy for Ayacut Development Under Major Irrigation Projects," Tungabhadra Project Achievements and Aspirations--1970, ed. Narasing Rao Madarkal. Bangalore: The Government Press, 1970.

_______. "Problems of Tungabhadra Project Ayacut Development in Raichur District," Tungabhadra: A Citadel of Hope, ed. Narasing Rao Madarkal. Bangalore: The Department of Information and Tourism, 1968.

Balogopalan, D. "Bellary--Bounty of Tungabhadra," Tungabhadra Project Achievements and Aspirations--1970, ed. Marasing Rao Madarkal. Bangalore: The Government Press, 1970.

Barker, Randolph and Bernard F. Stanton. "Estimation and Aggregation of Firm Supply Functions," Journal of Farm Economics, Vol. 47, No. 3, August, 1965.

Bhaktul, J. R. Package of Practices on Kharif Crops, 1970-71. Raichur: Department of Agriculture, 1970.

_______. Our Farmers Speak About High Yielding Varieties. Raichur: Department of Agriculture, 1970.

_______. Demonstration Results 1968 and 1969. Raichur: Department of Agriculture, 1969.

Biradar, S. K. "Innovations in Agriculture in T. B. P. Area," Tungabhadra Project Achievements and Aspirations--1970, ed. Narasing Rao Madarkal. Bangalore: The Government Press, 1970.

Bisaliah, S. and Donald C. Taylor. "An Economic Analysis of Major Irrigated Crops in the Tungabhadra Irrigation Project," University of Agricultural Sciences, Bangalore, an unpublished bulletin, 1971.

Cox, Murray P. A letter containing land leveling data written to John T. Phelan, US/AID, New Delhi, dated December 8, 1970.

Cultivation Practices for Vegetables. Bangalore: Director of Extension, University of Agricultural Sciences, 1970.

"Distributarywise Localization Statement for Distributaries 36 to 56," Executive Engineer PWD, Sindhanur, an unpublished bulletin, 1969.

Handbook on Irrigation Water Management. New Delhi: Department of Agriculture, 1970.

Jones, Don and B. R. Hayavadanachar. "Enterprise Budgets on Crops Grown on Black Soils Under the LBLLC and LBHLC and on Red Soils Under the LBLLC," Regional Pilot Project for Soil and Water Management, Bellary, an unpublished paper, 1969.

Joshi, N. G. "Constructional and Irrigation Aspects of TBP," Tungabhadra: A Citadel of Hope, ed. Narasing Rao Madarkal. Bangalore: The Department of Information and Tourism, 1968.

Kester, Gerald and A. S. Puttu Ram. "A Comparative Study of the Water Used in Growing Paddy on Contrasting Soils in the Tungabhadra Command Area," Regional Pilot Project for Soil and Water Management, Bellary, an unpublished paper, 1970.

Madarkal, Narasing Rao. "Statement Showing Distributarywise Localized Area for Distributaries on the Left Bank Canal," Deputy Administrator, TBP, Sindhanur, an unpublished bulletin, 1969.

Miller, Thomas. "Aggregation Error in Representative Farm Linear Programming Estimates," Ph.D. dissertation, Iowa State University, 1967.

Mysore State in Maps--1966. Bangalore: The Government Press, 1968.

Package of Practices for High Yields. Bangalore: University of Agricultural Sciences and Department of Agriculture, 1970.

Patil, S. V. and B. V. Venkata Rao. Effects of Irrigation on Black Soils in the Tungabhadra Project Area in Mysore State. Bangalore: University of Agricultural Sciences, 1965.

Project Work Plan: Regional Pilot Project for Soil and Water Management, Bellary, Mysore State. Bangalore: Government of India, 1969.

Rao, B. V. Venkata. Soil Resources of Mysore. Bangalore: University of Agricultural Sciences, 1968.

Ray, Robert M. and Herbert N. Walch. Farm Management Manual. Bulletin EC622. Knoxville: Tennessee Agricultural Extension Service, 1969.

Reddy, C. Nanja, K. C. Hiremath, and Estel H. Hudson. "Farm Planning Manual," University of Agricultural Sciences, Bangalore, an unpublished bulletin, 1970.

_______, and K. V. Govinda Raju. "Farm Management Studies in Mysore State," Department of Agriculture, Hebbal, Bangalore, an unpublished paper, 1969.

Report of the Expert Committee on the Development of Light Irrigation on the Left Bank Area of the Tungabhadra Project. Bangalore: Department of Agriculture, 1965.

Revanna, C. M. "Development of TBP Ayacut in Raichur and Bellary Districts," Tungabhadra: A Citadel of Hope, ed. Narasing Rao Madarkal. Bangalore: The Department of Information and Tourism, 1968.

Sharples, Jerry. "The Representative Farm Approach to Estimation of Supply Response," American Journal of Agricultural Economics, Vol. 51, No. 2, May, 1969.

_______, Earl O. Heady, and Mahmond M. Sherif. Potential Agricultural Production and Resource Use in Iowa. Research Bulletin 569. Ames: Iowa Agriculture and Home Economics Experiment Station, Iowa State University of Science and Technology, 1969.

Supplementary Sources

Achar, H. P. A personal interview at Siruguppa, February 23, 1971.

Agha, C. A personal interview at Sindhanur, February 8, 1971.

Babu, S. A personal interview at Sindhanur, February 22, 1971.

Basavaraj, R. A personal interview at Sindhanur, December 11, 1970.

Bellary, A. B. A personal interview at Sindhanur, December 11, 1970.

Cox, Murray. Personal interviews at Bangalore, March, 1971.

Gowda, N. V. A personal interview at Hebbal, March 4, 1971.

Haslim, Don. A personal interview at Bellary, February 23, 1971.

Hayavadanachar, B. R. A personal interview at Bellary, February 23, 1971.

Jayaramiah, Parmasappa, and Khan. Personal interviews and field trip at Gangavati A. R. S., at Gangavati, February 9, 1971.

Joshi, N. G. A personal interview at Hospet, February 22, 1971.

Madarkal, Narasing Rao. A personal interview at Sindhanur, February 8, 1971.

Mahurker, C. M. A personal interview at Sindhanur, January 25, 1971.

Mohanrao, S. A personal interview at Sindhanur, January 25, 1971.

Murthy, R. S. A personal interview at Bangalore, November 12, 1970.

Panchal, Y. C. and V. S. Patil. Personal interviews at Siruguppa, January 27, 1971.

Patil, S. V. Personal interviews at MUAS in Bangalore, December, 1970.

Patil, S. V. A personal interview at Sindhanur, February 8, 1971.

Rao, Laxami. A personal interview at Sindhanur, February 8, 1971.

Rao, T. S., S. Usman and A. Nadugowda. Personal interviews at Raichur A.R.S. at Raichur, January 26, 1971.

Reddy, C. Nanja. Personal interviews at Bangalore, January, 1971.

Sawkar, R. B. A personal interview at Dhadesugar, January 27, 1971.

Shaw, E. W. A personal interview at Bellary, February 23, 1971.

Srinivasachar, M. A personal interview at Hagari A.R.S. at Hagari, February 9, 1971.

Taylor, Donald C. and S. Bisaliah. Personal interviews at Bangalore, December, 1970.

Vamanaacharya, A. A personal interview at Sindhanur, February 8, 1971.

APPENDIXES

APPENDIX A

THE SURVEY QUESTIONNAIRE

QUESTIONNAIRE

Name______________________________ Village___________________________
(Selected in sample)

Respondent________________________ Educational level_________________
(Probably same as above)

*1. LAND AND WATER

1) Of the land you operate how much is developed for growing?

	Operated	Owned
a. Paddy (wet)	_____	_____
b. Light irrigated (D.C.W.)	_____	_____
2) Rainfed	_____	_____

3) How did you develop your land--machine/bullocks/both?

4) Total cost of development Paddy — Acres_______________

Cost_______________

D.C.W. Acres_______________

Cost_______________

5) Of the land you operate how much is localized for

	Operated	Owned
a. Paddy (wet)	_____	_____
b. Light irrigated (D.C.W.)	_____	_____
i. Kharif	_____	_____
ii. Rabi	_____	_____
iii. Cotton	_____	_____

____

*Indicates those questions that are particularly pertinent to Cashdollar's study. Other questions are particularly pertinent to Paramasiviah's study.

	Operated	Owned
c. Garden (Perennial)	_____	_____

6) a. Do you own any land you do not operate? Yes No

b. If yes, how many acres? ____________

2. CROPS

1) List crop, variety, irrigation, yield, and acres in the table below for 1969-70 (June 69 to May 70).

Crop Variety	Kharif			Rabi			Summer		
	Irri-gation	Acres	Yield	Irri-gation	Acres	Yield	Irri-gation	Acres	Yield

2) If you have grown more than one crop on a particular piece of land, give sequences followed.

Tract	Kharif	Rabi	Summer
1.			
2.			
3.			

3) How much fertilizer was used for (major season)?

	N	P_2O_5	K_2O	Plant Protection	
				Yes No	No. of times
(1) Paddy (HYV) (Local)					
(2) Cotton (HYV) (Local)					
(3) Jowar (HYV) (Local					
(4) Wheat (HYV) (Local)					

4) Sources of obtaining the following inputs.

	Local Merchant		Cooperative	
	Qty.	Value	Qty.	Value
1. Fertilizers				
a.				
b.				
c.				
d.				
2. Seeds				
a.				
b.				
c.				
d.				
e.				
3. Plant Protection Chemicals				
F.Y.M.				

	Agric. Dept.		Sindhanoor Market	
	Qty.	Value	Qty.	Value
1. Fertilizers				
a.				
b.				
c.				
d.				
2. Seeds				
a.				
b.				
c.				
d.				
e.				
3. Plant Protection Chemicals				
F.Y.M.				

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5) Owned inputs used.

	Quantity	Value
1. F.Y.M.		
2. Seeds		
a.		
b.		
c.		
d.		
e.		

---

6) Marketing source and quality of produce.

Crop	Cooperative (Sindhanoor)	Sindhanoor Market	Regulated Market at Raichur	Local Trade	Remarks
1.					
2.					
3.					
4.					
5.					
6.					

Why you sold to the source mentioned above (check)

	1	2	3	4	5	6
a. Got better price						
b. Did not have transportation						
c. Only had small amount						
d. Had to sell because I had borrowed money						

*3. LABOR (1969-70)

1) Family labor who do some work (actual and available)

Members	June AC	June AV	July AC	July AV	Aug. AC	Aug. AV	Sept. AC	Sept. AV	Oct. AC	Oct. AV	Nov. AC	Nov. AV
1.												
2.												
3.												
4.												
5.												
6.												
7.												
Bullocks												
(2) Permanent Servants												
1.												
2.												
3.												

Members	Dec.		Jan.		Feb.		Mar.		Apr.		May	
	AC	AV	AC	AV	AC	AV	AC	AV	AC	AV	AC	AV
1.												
2.												
3.												
4.												
5.												
6.												
7.												
Bullocks												
(2) Permanent Servants												
1.												
2.												
3.												

How long is the normal work day? _______ Family
_______ Permanent Servant

*3) a. How many days of casual labor did you hire last year by
Men Women Children Bullocks

b. In what month did you hire the most casual labor?____________

How many days did you hire (Hours/day______________)
Men Women Children

c. Could you have hired more labor during this month if you had needed it (at present wage rate)? Yes No

d. Is this much labor available to you for hire during all months if you need it? Yes No If no, why?

e. What is the daily wage for casual labor during busiest month?
Men Women Children

*4) What farming operations did you have performed, either wholly or partially by custom labor during 1970?

	Machine/power if any	Rate/Unit
1.		
2.		
3.		
4.		

*5) Are there any farming operations in which women, children, men, never engage? What operations?

	Operations	Men	Women	Children
1.				
2.				

3. For those checked why do they not?

*4. CAPITAL AND CREDIT

1) Assets Owned — Present Market Value

a. Tractor & attachments
b. Bullocks
c. Bullock carts
d. Others (above Rs. 150/=)
e. Cash on hand
f. Value of livestock other than bullocks

*2) Loan Statement

	Sources	Short Term	Medium Term	Long Term	Others (Specify)	Remarks
Government	Amount					
	Year					
	Purpose					
	Interest					
	Amt. repaid					
Cooperative	Amount					
	Year					
	Purpose					
	Interest					
	Repayment					
Commercial Bank	Amount					
	Year					
	Purpose					
	Interest					
	Repayment					

	Sources	Short Term	Medium Term	Long Term	Others (Specify)	Remarks
Others (Specify)	Amount Year Purpose Interest Repayment					
Total Amount						

*3) Other sources of income Rs./year.

*4) If you have lived in Sindhanoor less than 15 years from where did you move and how long have you been here?

APPENDIX B

CROP PRODUCTION DATA

TABLE A-1

CROP BUDGET FOR DRYLAND WHEAT GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Grain	Quintal	2.5	109.00	272.50
Fodder	M. Ton	.5	14.00	7.00
Total Revenue				279.50
Variable Expenses				
Cash Expenses				
Seed	Kg.	30.0	1.50	45.00
N	Kg.	20.0	2.59	51.80
P_2O_5	Kg.	10.0	2.72	27.20
Chemicals	--	--	--	10.00
Total Cash Expenses				134.00
Noncash Expenses				
Repair and Depreciation on Implements				6.00
Total Noncash Expenses				6.00
Total Expenses				140.00
Net Returns				139.50

TABLE A-2

CROP BUDGET FOR DRYLAND SAFFLOWER GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Oilseed	Quintal	2.5	142.00	355.00
Total Revenue				355.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	3.7	1.00	3.70
N	Kg.	15.0	2.59	38.80
P_2O_5	Kg.	10.0	2.72	27.20
K_2O	Kg.	10.0	.88	8.80
Total Cash Expenses				78.50
Noncash Expenses				
Repair and Depreciation on Implements				5.20
Total Noncash Expenses				5.20
Total Expenses				83.70
Net Returns				271.30

TABLE A-3

CROP BUDGET FOR DRYLAND JOWAR (M35-1), GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees-------	
Revenue				
Grain	Quintal	5.0	79.00	395.00
Fodder	M. Ton	1.5	15.00	22.50
Total Revenue				417.50
Variable Expenses				
Cash Expenses				
Seed	Kg.	4.0	1.10	4.40
N	Kg.	20.0	2,59	51.80
P_2O_5	Kg.	15.0	2.72	40.80
K_2O	Kg.	10.0	.88	8.80
Chemicals	--	--	--	5.00
Total Cash Expenses				110.80
Noncash Expenses				
Repair and Depreciation on Implements				5.70
Total Noncash Expenses				5.70
Total Expenses				116.50
Net Returns				301.00

TABLE A-4

CROP BUDGET FOR DRYLAND COTTON (HAMPI), GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Seed Cotton (Kapas)	Quintal	1.75	197.00	344.70
Total Revenue				344.70
Variable Expenses				
Cash Expenses				
Seed	Kg.	3.00	1.10	3.30
N	Kg.	10.00	2.59	25.90
P_2O_5	Kg.	8.00	2.72	21.70
K_2O	Kg.	4.00	.88	3.50
Chemicals	--	--	--	15.00
Total Cash Expenses				69.40
Noncash Expenses				
Repair and Depreciation on Implements				8.80
Total Noncash Expenses				8.80
Total Expenses				78.20
Net Returns				266.50

TABLE A-5

CROP BUDGET FOR IR-8 PADDY GROWN DURING KHARIF SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Grain	Quintal	20.0	55.0	1100.00
Fodder	M. Ton	3.0	15.00	45.00
Total Revenue				1145.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	20.0	1.00	20.00
FYM	M. Ton	4.0	10.60	42.40
N	Kg.	60.0	2.59	155.40
P_2O_5	Kg.	30.0	2.72	81.60
K_2O	Kg.	30.0	.88	26.40
Chemicals	--	--	--	24.00
Total Cash Expenses				349.80
Noncash Expenses				
Repair and Depreciation on Implements				8.10
Total Noncash Expenses				8.10
Total Expenses				357.90
Net Returns				787.10

TABLE A-6

CROP BUDGET FOR IRRIGATED SAFFLOWER (A-300), GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Oilseed	Quintal	5.0	142.00	710.00
Total Revenue				710.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	4.0	1.00	4.00
FYM	M. Ton	2.0	10.60	21.20
N	Kg.	30.0	2.59	77.70
P_2O_5	Kg.	15.0	2.72	40.80
K_2O	Kg.	15.0	.88	13.20
Chemicals	--	--	--	10.00
Total Cash Expenses				166.90
Noncash Expenses				
Repair and Depreciation on Implements				7.80
Total Noncash Expenses				7.80
Total Expenses				174.70
Net Returns				535.30

TABLE A-7

CROP BUDGET FOR IRRIGATED COTTON (HAMPI), GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Seed Cotton (Kapas)	Quintal	5.0	197.00	985.00
Total Revenue				985.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	3.0	1.10	3.30
FYM	M. Ton	2.0	10.60	21.20
N	Kg.	30.0	2.59	77.70
P_2O_5	Kg.	15.0	2.72	40.80
K_2O	Kg.	15.0	.88	13.20
Chemicals	--	--	--	95.00
Total Cash Expenses				251.20
Noncash Expenses				
Repair and Depreciation on Implements				14.00
Total Noncash Expenses				14.00
Total Expenses				265.20
Net Returns				719.80

TABLE A-8

CROP BUDGET FOR IRRIGATED MEXICAN WHEAT GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees-------	
Revenue				
Grain	Quintal	9.0	109.00	981.00
Fodder	M. Ton	1.5	14.00	21.00
Total Revenue				1002.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	50.0	1.50	75.00
FYM	M. Ton	2.0	10.60	21.20
N	Kg.	50.0	2.59	129.50
P_2O_5	Kg.	30.0	2.72	81.60
K_2O	Kg.	20.0	.88	17.60
Chemicals	--	--	--	10.00
Total Cash Expenses				334.90
Noncash Expenses				
Repair and Depreciation on Implements				6.60
Total Noncash Expenses				6.60
Total Expenses				341.50
Net Returns				660.50

TABLE A-9

CROP BUDGET FOR IRRIGATED JOWAR (M35-1), GROWN DURING RABI SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Grain	Quintal	10.0	79.00	790.00
Fodder	M. Ton	3.0	15.00	45.00
Total Revenue				835.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	4.0	1.10	4.40
FYM	M. Ton	2.0	10.60	21.20
N	Kg.	50.0	2.59	129.50
P_2O_5	Kg.	30.0	2.72	81.60
K_2O	Kg.	15.0	.88	13.20
Chemicals	--	--	--	23.60
Total Cash Expenses				273.50
Noncash Expenses				
Repair and Depreciation on Implements				7.80
Total Noncash Expenses				7.80
Total Expenses				281.30
Net Returns				553.70

TABLE A-10

CROP BUDGET FOR IRRIGATED BAJRA (HB-1), GROWN DURING KHARIF OR SUMMER SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Grain	Quintal	8.0	66.00	528.00
Fodder	M. Ton	2.2	15.00	33.00
Total Revenue				561.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	2.0	7.50	15.00
FYM	M. Ton	2.0	10.60	21.20
N	Kg.	40.0	2.59	103.60
P_2O_5	Kg.	25.0	2.72	68.00
K_2O	Kg.	10.0	.88	8.80
Chemicals	--	--	--	5.00
Total Cash Expenses				221.60
Noncash Expenses				
Repair and Depreciation on Implements				8.50
Total Noncash Expenses				8.50
Total Expenses				230.10
Net Returns				330.90

TABLE A-11

CROP BUDGET FOR IRRIGATED NAVANE GROWN DURING KHARIF, RABI, OR SUMMER SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Grain	Quintal	8.0	60.00	480.00
Fodder	M. Ton	2.2	15.00	33.00
Total Revenue				513.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	4.0	1.25	5.00
FYM	M. Ton	2.0	10.60	21.20
N	Kg.	40.0	2.59	103.60
P_2O_5	Kg.	25.0	2.72	68.00
K_2O	Kg.	10.0	.88	8.80
Chemicals	--	--	--	10.00
Total Cash Expenses				216.60
Noncash Expenses				
Repair and Depreciation on Implements				9.50
Total Noncash Expenses				9.50
Total Expenses				226.10
Net Returns				286.90

TABLE A-12

CROP BUDGET FOR IRRIGATED JOWAR (CSH-1), GROWN DURING KHARIF OR SUMMER SEASON SHOWING PRODUCTION AND TOTAL REVENUE, CASH AND NONCASH EXPENSES, AND NET RETURNS PER ACRE

Item	Unit	Quantity	Price	Amount
			-----Rupees------	
Revenue				
Grain	Quintal	10.0	79.00	790.00
Fodder	M. Ton	3.0	15.00	45.00
Total Revenue				835.00
Variable Expenses				
Cash Expenses				
Seed	Kg.	4.0	2.40	8.20
FYM	M. Ton	2.0	10.60	21.20
N	Kg.	50.0	2.59	129.50
P_2O_5	Kg.	30.0	2.72	81.60
K_2O	Kg.	15.0	.88	13.20
Chemicals	--	--	--	23.60
Total Cash Expenses				277.30
Noncash Expenses				
Repair and Depreciation on Implements				7.80
Total Noncash Expenses				7.80
Total Expenses				285.10
Net Returns				549.90

TABLE A-13

DEPRECIATION AND REPAIR COSTS FOR IMPLEMENTS USED IN RUPEES

Implement	New Cost	Depreciation Per Hour	Repairs Per Hour	Total Depreciation and Repairs Per Hour
Bullock Cart	650	.06	.04	.10
Plough, wooden, light to medium, W4",D4"	30	.03	.04	.07
Harrow, full blade, D2", W36"	30	.034	.076	.11
Harrow, full blade, D2", W18"	15	.02	.04	.06
Harrow, wooden, with spikes, W6'	22	.025	.055	.08
Seed drill, 2 row	45	.025	.015	.04
Seed-cum-fertilizer drill, 3 row	85	.05	.06	.11
Sprayer, gator or knapsack	175	.20	.13	.33

Source: S. Bisaliah and Donald C. Taylor, "An Economic Analysis of Major Irrigated Crops in the Tungabhadra Irrigation Project," University of Agricultural Sciences, Bangalore, an unpublished paper, 1971, pp. 9-10.

TABLE A-14

MAN-HOURS AND BULLOCK PAIR HOURS REQUIRED PER ACRE FOR DRYLAND AND IRRIGATED CROPS

Crop	Man-Hours of Labor Required	Bullock Pair Hours Required
Dryland Crops		
Wheat	151	63
Jowar	191	68
Cotton	197	67
Safflower	191	69
Irrigated Crops		
Paddy	626	94
Wheat	301	73
Jowar	351	87
Cotton	384	79
Safflower	406	83
Bajra	300	85
Navane	320	85

VITA

Parker Ditmore Cashdollar was born in Dyer County, Tennessee, on September 6, 1942. He attended the public schools in Newbern, Tennessee, and graduated from Newbern High School in 1960. He received a Bachelor of Science degree in Agricultural Economics from the University of Tennessee at Knoxville in June, 1964.

After graduation, he worked as Assistant County Supervisor for the Farmers Home Administration in Union City, Tennessee. In August, 1965, he was appointed County Supervisor for the Farmers Home Administration in Clarksville, Tennessee, where he worked until September, 1968.

He entered Graduate School at the University of Tennessee in September, 1968, and received the Master of Science degree with a major in Agricultural Economics in March, 1970. From November 1970 through March 1971 Cashdollar and his family were in Mysore State, India, where he collected data for his doctoral dissertation. He received the Ph.D. in Agricultural Economics in December, 1971. In September 1971, he accepted a position as Assistant Professor of Economics at the University of Tennessee at Martin.

He is married to the former Sophie Joyce Huie of Yorkville, Tennessee. They have one son, Hunter Huie.