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IRIES
Irrigation Impact Evaluation System

An Evaluation of the Direct & Indirect Impacts of Irrigation on come, Employment & Health in the State of Maharashtra, India

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with the assistance of:
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Prepared for:
Irrigation Department
Government of Maharashtra
Bombay, India

Under Contract to:
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Executive Summary

Objectives>> This analysis examines the direct and indirect income, employment and health impacts of irrigation in Maharashtra through the evaluation of three projects, Mula (a major project in drought prone Ahemednagar district), Chulband (a medium scale project in the assured rainfall district of Bhandara), and Sidhanath (a minor scale project in the scarcity rainfall district of Sangli). The objective of this effort is two-fold, first to use control group surveys to estimate irrigation impacts, and secondly to develop standardized computer models which can be used to replicate the analysis on other projects. This analysis and its methods grew out of an earlier review by the authors of exist irrigation impact studies which suggested a scarcity of field survey based evaluation studies on irrigation impact in India[1].

Two survey and analysis options were developed, a Rapid Appraisal option which can be used to evaluate a project in a period of six weeks, and a Comprehensive Evaluation option which will provide additional detail and reliability but requires approximately six months to complete.

Economic Rates of Return>> Figure one and Table I summarize the economic rates of return estimated from the Rapid Appraisal sample surveys. The Mula project ERR is a very favorable 19.5%, more than seven percent above the frequently used international minimum target of 12%. This ERR is higher than any of the 14 Major project ERR's reviewed in the 1987 literature review (see footnote 1).

Chulband (the medium project evaluated) had the lowest ERR of the three, at 9.77% which is well below the 12% frequently used target rate and approximately in the middle range of the four medium project ERRs reviewed in 1987.

The minor project surveyed, Sidhanath had an intermediate ERR at 15.9% .

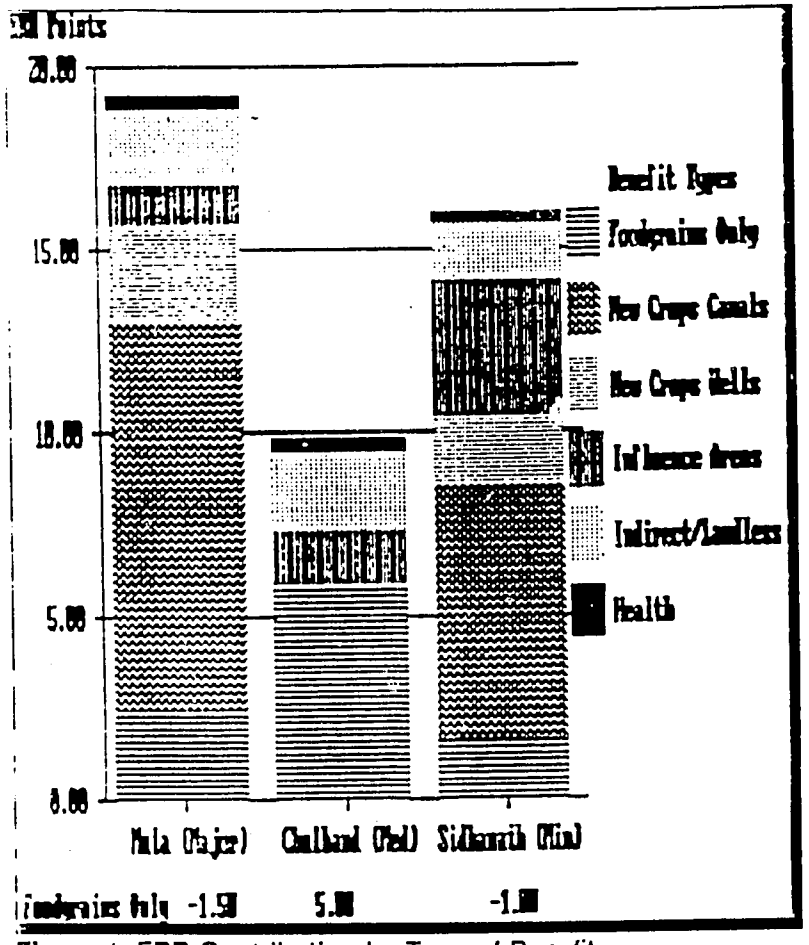

Figure 1: ERR Contribution by Type of Benefit

Direct & Indirect Benefit Contributions>> Figure one and Table I outline the relative contributions of six major direct and indirect benefit types to each of the project's ERR's. By far the single most important benefit for the two projects with high ERRs was derived from the introduction of new non-foodgrains crops under canal irrigation inside the Mula and Sidhanath commands. This factor is conspicuously absent in the case of the low ERR project, Chulband and may be said to be the determining difference between high and low returns.

In order to understand the relative contributions of different kinds of associated with the introduction of irrigation, the analysis classified benefits into the six categories in Table I. These categories and their statistical basis are discussed in the body of the report, a simplified version of their definition is used here for purposes of brevity.

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[1] See, S. Daines & J R. Pawar, Economic Returns to Irrigation in India, SRD Research Group Inc, Logan Utah, for U.S. Agency for International Development, New Delhi, 1987 95 pp.

Foodgrains>> This benefit category includes income increases resulting from improved yields and/or increased areas planted in foodgrains crops which existed in the region before irrigation was introduced. It is useful to note that yield improvement and stabilization and cropped area increases in foodgrains may be fairly said to be the collective *raison de etre* of Indian irrigation, yet in both high return cases these factors accounted for less than 15% of total benefits even if their indirect impacts are added in. The fact that foodgrain yield improvement and area cropped increases were the only large contributing benefit factor in the case of the under-performing system suggests that foodgrain yield and area increases cannot pay for the level of investment required for these types of projects in Maharashtra.

The last row in Table I outlines the ERR which would have resulted in each project if direct income from foodgrain yield and area increases were the only benefit. These estimates are usable without further adjustment in the cases of Mula and Sidhanath[2] and indicate that the ERR would have been less than zero if based only on foodgrain yield and cropped area increases. Since the only significant direct benefit measured for Chulband was in foodgrains, all indirect benefits must also have been derived therefrom. Thus the full 9.77% ERR should be accounted to foodgrains for Chulband rather than the 5.81 which results from the allocation formula used in Table I.

Even after these adjustments are made, a basic conclusion emerges intact, that at least in these three projects the most often advanced *raison de etre* of for Indian irrigation was hardly reason enough.

Table I: ERR Contribution by Benefit Type

	Mula (Major)	Chulband (Medium)	Sidhanath (Minor)
Health	0.38	0.35	0.29
Indirect/Landless	2.05	2.16	1.53
Influence Areas	1.11	1.45	3.74
New Crops Wells	2.71	0.00	1.80
New Crops Canals	10.56	0.00	7.00
Foodgrains	2.33	5.81	1.55
Total ERR	19.15	9.77	15.90
Foodgrains ERR	-1.50	5.81	-1.88

New Crops on Canals & Wells>> Crop diversification benefit of irrigation, defined herein as the income resulting from the introduction of non-foodgrains irrigated crops not present before irrigation, contributed 13.27% or roughly 85% of the direct contributing factors in the Mula ERR. More than this proportion of the indirect employment and influence area benefits came from this factor making it clearly the dominant effect in the best performance case. A similar pattern is apparent in Sidhanath, but clearly not the case in the low-performance case of Chulband where no significant benefits accrued from crop diversification at all. Thus an effect which some irrigation regulations and practices in Maharashtra have even sought on occasion to limit appears to be the income and employment engine of high system performance.

A significant portion of the crop diversification benefit has come from wells inside the Mula and Sidhanath commands and also on wells outside the command which lie in the area where groundwater recharge from the systems directly affects groundwater supplies.

[2] This somewhat underestimates the fair allocation of total benefits which would have resulted from foodgrains impacts alone since it does not include the indirect employment and health benefits correctly allocable to foodgrains. Even adjusting for these benefits would not increase the "Foodgrains ERR" as shown in Table I for Mula and Sidhanath by more than 1 point. Thus, the basic conclusion that both of these projects would have negative ERR's based only on foodgrain benefits would be true even if adjusted for indirect impacts.

This is particularly true of Sidhanath where roughly half of the income impact of diversification has resulted from wells developed at least in large part from recharged groundwater supplies.

Groundwater, Lift & Economic Influence Area Benefits>> The "Influence Areas" category in Figure 1 and Table I refer to income benefits associated with irrigation occurring to farms and families outside the commands in those close areas "influenced" by the irrigation project. The survey defined and sampled farms and families in three types of "influence" areas; (1) those located in the "groundwater" influence area where system recharge benefits well water supply; (2) those located in "lift" areas where canal or tank water is pumped for irrigation; and (3) those farms or landless families located in communities close to the command where family employment opportunities in sugar mills etc. exist because of irrigation. The income benefit of irrigation to these "influence" areas is most significant in the case of the Sidhanath groundwater influence area which accounts for approximately 20% of total ERR.

Indirect Employment and Landless Family Benefits>> The indirect and landless benefit category refers to those income benefits from irrigation which flow from indirect (non-crop) employment of farm and landless families living inside the command. These benefits include all livestock benefits which for accounting convenience were not considered as "direct crop" incomes[3]. While these impacts do not appear to have made large ERR contributions in any project case, their importance in an equity sense is larger than their absolute size since most of these benefits flow to the unemployed and most disadvantaged group, the landless poor. In both of the high performance cases, these indirect impacts were larger than influence area impacts, and in the Mula project, the indirect benefits of this type were larger contributors to economic return than foodgrain yield and cropped area increases. The fact that indirect employment and processing benefits are much larger for the new crops than for foodgrains per unit of land AND per unit of water emphasizes the importance of diversification for the welfare of the disadvantaged weaker sectors dominated by the landless.

Health Impacts of Irrigation>> The sample surveys estimated the numbers of days of work lost through illness. Two contradicting irrigation effects appear to be at work. In the large Mula system it appears that proximity to standing water associated with tanks, wells and rivers appears to be associated with increased average illness rates. However, most of this water proximity associated problem apparently existed before irrigation simply because of the nearness of perennial rivers and streams. The introduction of irrigation appears to have had a substantial positive impact on reducing the illness gap between "dry landers" and "wet landers" before irrigation, in spite of the fact that the tank and wells have increased the volumes of standing water. Thus there is a significant reduction by almost half in the number of ill days associated with irrigation in the Mula, with a lesser but still noticeable effect in Sidhanath. To translate these benefits into economic terms for inclusion in the ERR arithmetic, we have valued the work days saved through illness reduction at 1/2 the going wage on the assumption that 50% of these saved days would be unemployed and hence without economic value lost. Viewed this way, health benefits account for 2-3% of the estimated ERRs.

3/ Beyond accounting convenience, the convention we adopted is reflective of the field reality that many families with very small house-yard sized plots of land are engaged in dairying and other livestock activities based on forage grown under irrigation. To keep the accounts clear we have accounted forage incomes as on-farm direct "crop" incomes and transferred the forage at market prices to "livestock" activities which are considered along with processing and marketing as "indirect" benefits.

A. Objectives & Methodology

1. IRIES Objectives.

The IRIES system was developed to meet the needs of irrigation evaluation of the Irrigation Department of Maharashtra. The project has two objectives, first to make the most complete and reliable estimates possible given the limited time and resources allotted of direct and indirect impacts of three selected irrigation projects. The second objective was to develop re-useable computer models and survey formats and to field test these in the three project evaluations. Irrigation Department personnel in the Directorate of Irrigation Research and Development in Pune have been trained in the use of the Rapid Appraisal survey methods and analysis models which have been completed and field tested.

2. Methodology

The project has developed two different options for conducting field survey based evaluation of irrigation projects, a low cost "Rapid Appraisal system, and a more costly Comprehensive Evaluation alternative. Survey formats and analytical models have been developed for both of these systems. Field surveys and analysis model verification have been completed. The Irrigation Department with the assistance of Mahatma Phule Agricultural University expect to complete field work on the comprehensive surveys by mid-year. The main differences between these two survey systems and their analytical models is outlined in Table II. Each option has its strengths and weaknesses. The obvious benefit of the Rapid Appraisal method is that it is relatively inexpensive and quick to complete and could therefore be feasibly applied to many projects in a short period of time. The in-depth character of the comprehensive survey and analysis will allow for examination of more issues with a higher degree of statistical reliability. For example the data and models designed for the comprehensive evaluation will allow for examination of farm size disaggregation, examination of management and design options integrating more detailed hydrological interactions.

Table II: Overview of Rapid Appraisal & Comprehensive Evaluation Options

	Rapid Appraisal	Comprehensive
Survey Control Groups	14-18 per command	20-26 per command
Survey Size	280-360 Families	700-900 Families
Survey Schedule Form	4 pages	80 pages
Estimated Cost/Command	US$ 3,000	US$ 15,000
Time to Complete	Six Weeks	Six Months
Analysis Models Utilized	Benefit/Cost Income Impact Employment Impact Health Impact	Benefit/Cost Income Impact Employment Impact Health Impact Design & Management Decision Model

In the rapid appraisal surveys 18 control groups were separately sampled with 20 random observation units interviewed in each stratum. This gave nine final analysis weighted analysis groups with 40 observations each. In Sidhanath and Chulband certain groups were not sampled due to their unimportance in these smaller commands. The final sample included approximately 920 farms or households interviewed during the month of January 1989. A simplified 4 page questionnaire was administered by local personnel selected and supervised by SRD Research Group Inc. In addition to the farm/landless household survey, SRD personnel undertook a "crop" input/output purposive survey of fifteen farms for all crops which appeared in the farm surveys. The simplified farm questionnaire obtained four main parameters on each crop in the farm, area planted, area irrigated from canals, area irrigated from wells, quantities harvested, and purchased input totals.

These basic farm specific data were then adjusted according to the data obtained in the crop surveys to provide the estimates used in the Rapid Appraisal evaluation models. The comprehensive survey schedule contains a complete recapitulation of detailed crop by crop input quantities and values, whereas the Rapid Appraisal gathers simplified area, yield and other indicators from one survey and combines them with per unit coefficients gathered from a second survey. The structure of the control groups for the rapid appraisal survey in each command was as follows:

Command Farms	Influence Area Farms	Control Farms & Landless Families
Head (40)	Groundwater (40)	Control Farms (40)
With Well (20)	With Well (20)	With Well (20)
W/O Well (20)	W/O Well (20)	Without Well (20)
Mid (40)	Lift Area (40)	Landless Families (80)
With Well (20)	With Well (20)	Command (20)
W/O Well (20)	W/O Well (20)	Groundwater Influence (20)
Tail (40)	Economic Infl Area (40)	Economic Influence (20)
With Well (20)	With Well (20)	Control Area (20)
W/O Well (20)	W/O Well (20)	

The results from the Rapid Appraisal survey were tabulated and the differences in arithmetic means for the sampled groups was utilized in the income, employment, health and benefit cost computer models whose results are reported in this document.

Figure 2 is a black & white version of one of the water use model computer screens from the comprehensive analysis system for the Mula Command. These comprehensive models have been partially elaborated based on the rapid survey data but their use is limited unless the fuller information available from the comprehensive surveys is included. Figures 3 and 4 on the following page display similar example screens, a water use "window" for Chulband and a labor use "window" for Sidhanath.

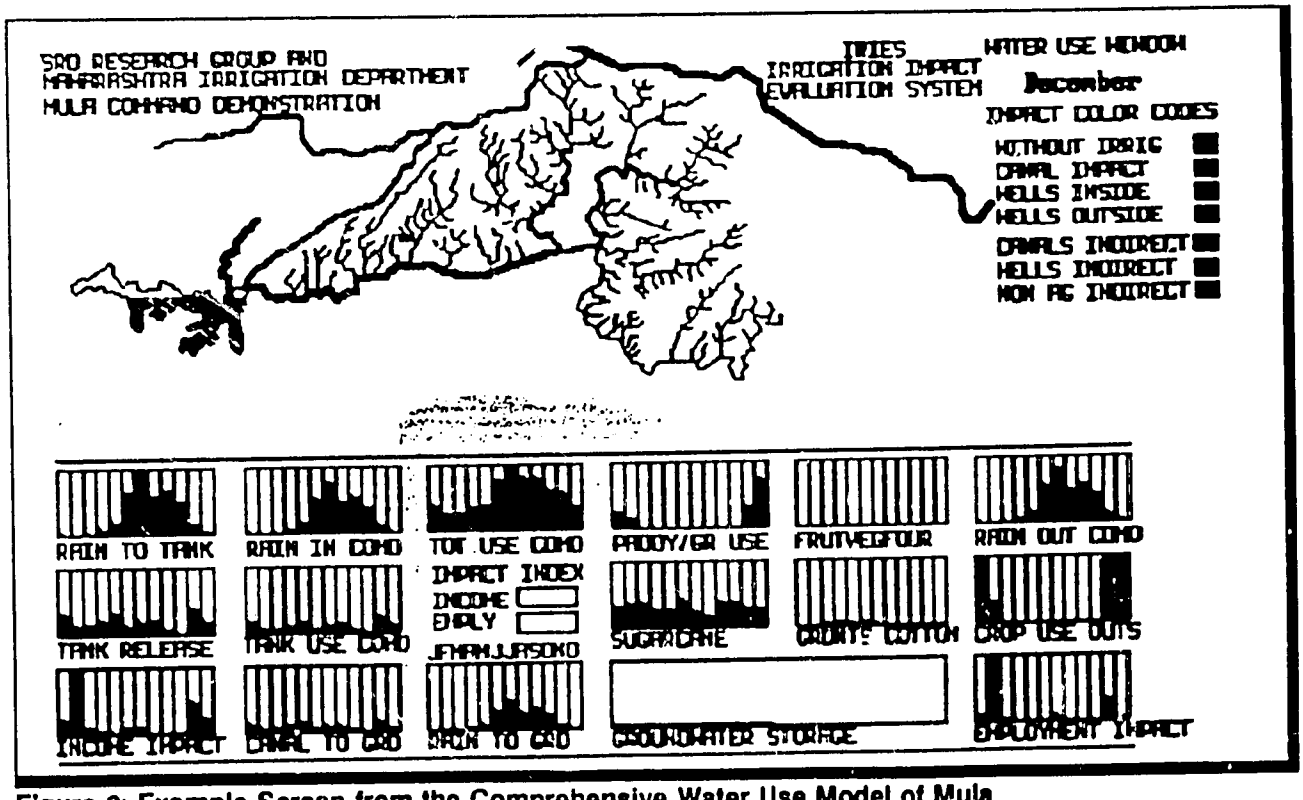

Figure 2: Example Screen from the Comprehensive Water Use Model of Mula

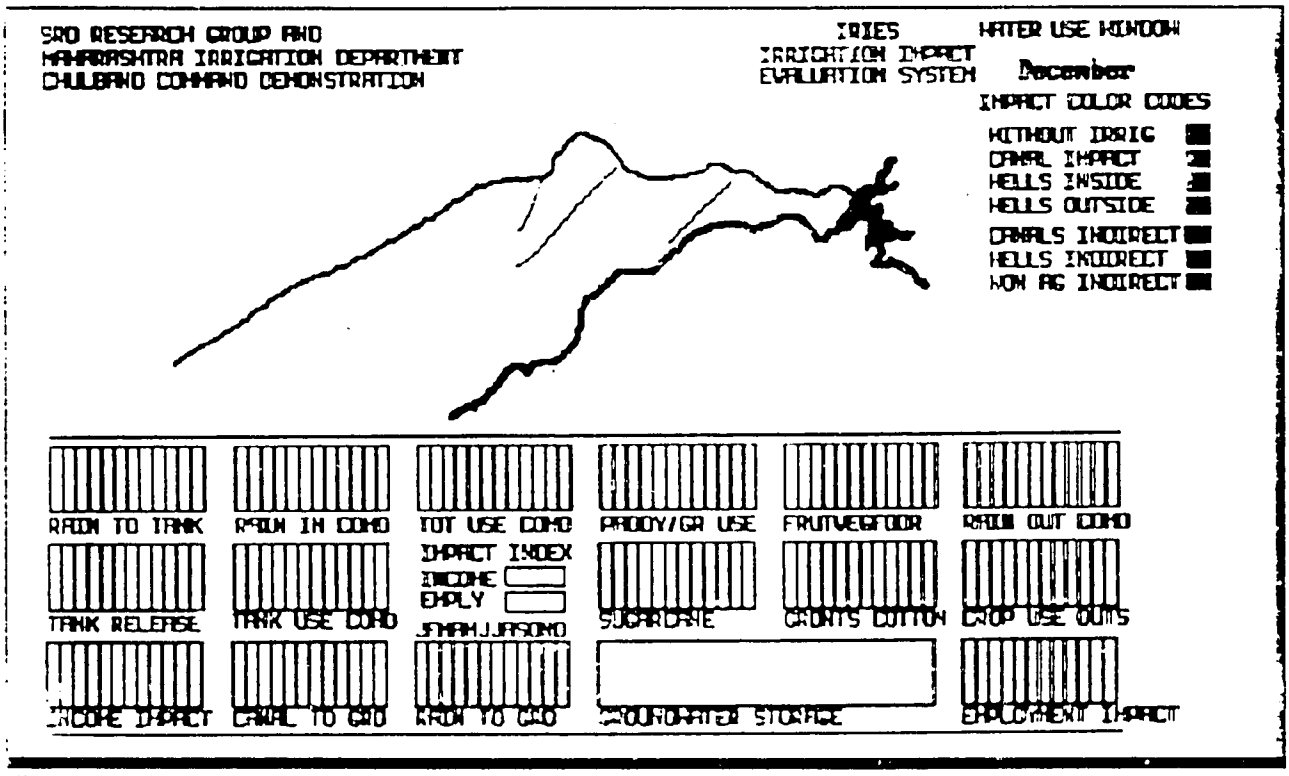

Figure 3: Example Water Use Screen from Chulband Comprehensive Model

The top part of these computerized design and management decision models displays information in scaled map format of the command and influence areas. The lower half of the screen summarizes scaled water, land and labor interactions in monthly bar graphs.

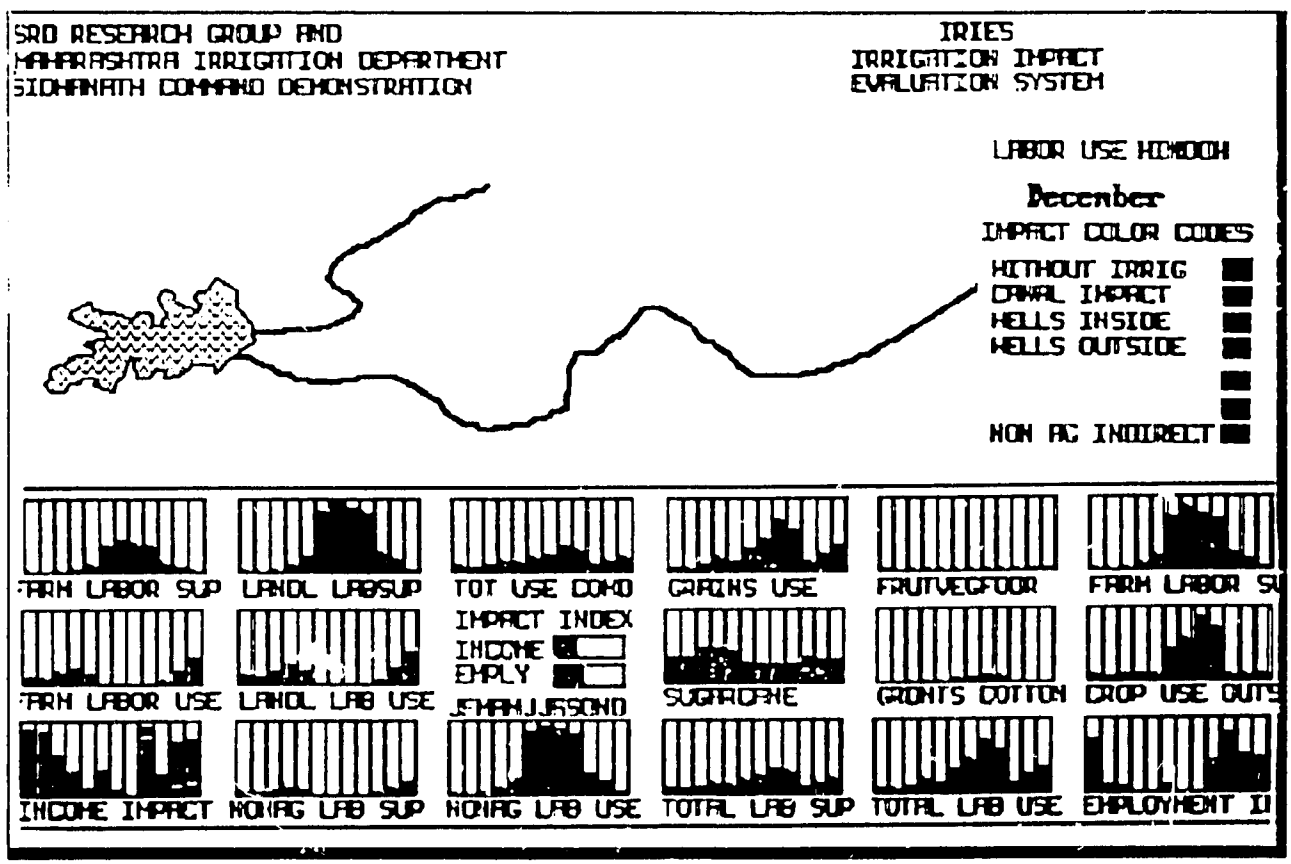

Figure 4: Example Labor Use Screen from Sidhanath Comprehensive Model

B. Benefit/Cost Analysis

1. The Mula Major Irrigation Project

The Mula is a major project commenced in 1959 and beginning to irrigate significant areas by 1973. It has a culturable command area of 118,000 hectares but net areas irrigated seldom exceed 35,000 hectares. There is a substantial lift benefitted area of over 13,000 hectares and there has been substantial investment in land levelling, roads and field channel construction. The project is located in a drought prone district in Western Maharashtra where un-irrigated cropping patterns are dominated by jowar (sorghum) and millets like bajra.

Figure 5 presents the cost and benefit flows computed for the Mula project discounted at 12% to reflect their net present values in 1986. The significant downturn in benefits observed after 1984 and continuing after 86 is due to the combined influence of the persistent drought ending in 1988, AND the effect of the 12% discount rate after 1986 which reduces benefits by 12% each year in the future.

Figure 5 provides the appropriate "picture" for viewing the integrated results of the benefit surveys and the project construction costs information provided by the Irrigation Department. In such a picture one

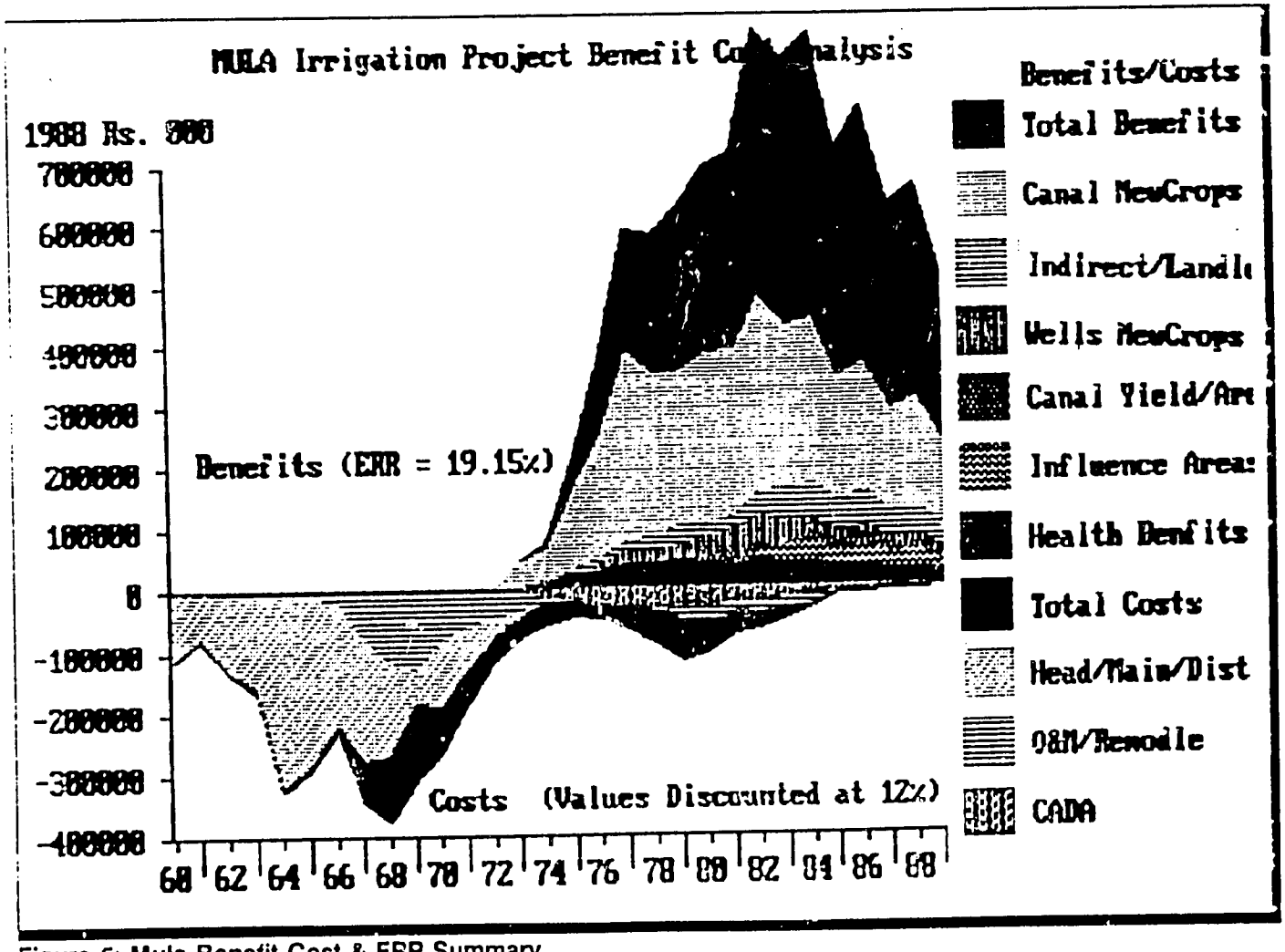

Figure 5: Mula Benefit Cost & ERR Summary

can see the relative weight of properly discounted cost and benefit flows and develop a visual sense of what a the costs and benefit flows of a "20% ERR" project look like. In addition to the small scale version of Figure 5 which is presented on this page, we have also included a full page version in Figure 6 where the smaller details relating to specific costs and benefits may be easily seen.

a. Costs

It is important to note the importance given by the discounting process to those costs which are incurred early in the construction process. For example, though the magnitude of expenditure on the headworks, main canals and distributories is not unlike the total spent on CADA and remodeling works, the discounted picture shows these early costs as dominating the cost side of the graphical ledger. This emphasizes the importance not only of controlling costs but also of controlling delays which imply lost opportunity value of sunk investments.

b. Benefits

Benefit flows for the Mula command are divided into six groups defined at pages ii & iii above. The relative contribution of each of these benefit types to Mula's impressive total ERR of 19.5% is given in Table III.

Table III: Mula ERR Contributions by Benefit Type

Health	0.38
Indirect/Landless	2.05
Influence Areas	1.11
New Crops Wells	2.71
New Crops Canals	10.56
Foodgrains	2.33
Total ERR	19.15
Foodgrains ERR	-1.50

Crop Diversification>> The dominant benefit type is the income to command farmers resulting from the cultivation of new crops not present without irrigation in the area with water from canals. This single factor accounted for more than three fourths of the total direct benefits of the project and for 10.56% of the total 19.5% ERR. Though sugarcane was the largest single new crop contributor during the early years, a wide variety of other crops including fodder crops, groundnuts, perennial fruits and vegetables all made significant contributions more recently.

As indicated in Table III, new crops grown with well irrigation inside the command was the second largest benefit contribution to the Mula ERR[3] with 2.71%. There is considerable overlap in irrigation on high cash crops like sugarcane, other perennial fruits, fodder crops and vegetables. The allocation made here was simply made based on the proportionate share of area which the survey farms reported having irrigated from each source.

Indirect Income>> Income benefits from indirect employment and related processing and marketing of crop products to farm and landless households inside the command was the third most important ERR contributor benefit type in the Mula project case. Indirect and landless benefits accounted for Among the most important of these activities were livestock activities and sugarcane secondary employment and benefits.

Foodgrain Yield and Cropped Area Increases>> Foodgrain yield improvements and increases in cropped area made only a 2.33% contribution to Mula's overall ERR.

[3] There is difference in the rankings given to this factor in Table III and in the graphs displayed in Figures 5 & 6. The reason for this difference is that the graphs simply present discounted benefits in absolute Rs. magnitudes graphed by year. The computation of relative contribution to ERR is more complicated because it does not start at zero but includes positive contributions from a negative position and reallocation of this absolute distance moved among the various factors. In making this allocation, direct crop benefit contribution factors were given a higher weight thus favoring direct crop benefits from wells over indirect employment. We would argue that for the purpose of ranking benefit contribution, Table III positions are more appropriate than the positions in the graphs.

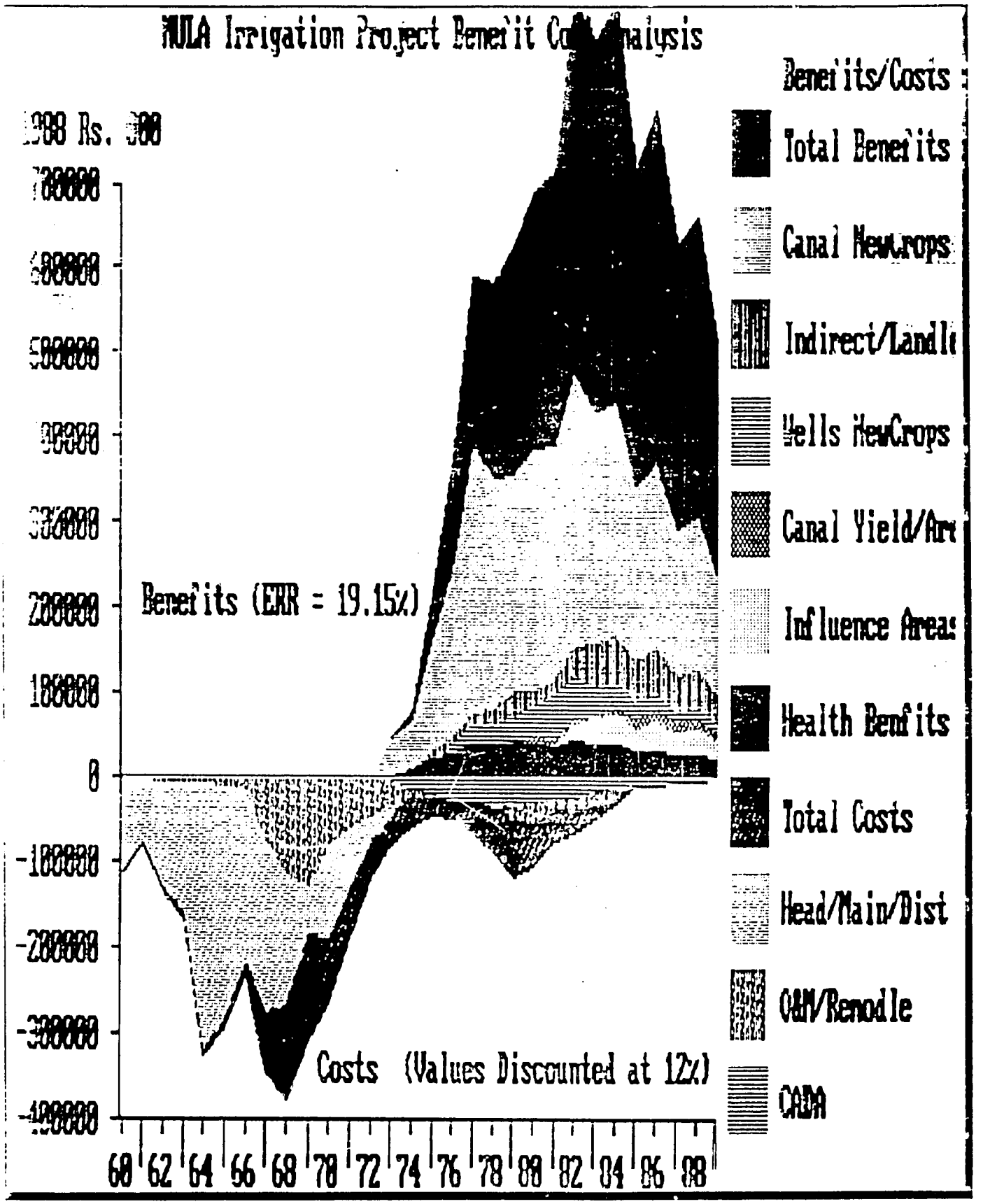

Figure 6: Mula Benefit Cost & ERR Summary

Since this is the most frequently assumed central purpose of Indian irrigation this contribution is both disappointing and instructive. In particular it is interesting to note that had foodgrain yield improvements and area cropped increases been the only source of benefit on the Mula command, instead of having an impressive 19.5% estimated ERR, the ERR would according to our data have been slightly negative. The ERR computed with direct foodgrain income benefits is only -1.5 and if indirect associated benefits are added in it is unlikely that it would increase by more than one additional percent leaving it slightly negative.

Influence Area Indirect Benefits>> Income benefits to farms and families in the groundwater. economic and lift benefit areas associated with irrigation accounted for a 1.1% contribution to Mula's ERR or just over a 5% share. Most of this impact came from the economic influence area where the increased pace of economic activity apparently created by the Mula command has opened significant opportunities.

Health Benefits>> Health benefits are described above at page iii and are analyzed in more detail in the health section below. The health impact of the Mula project, while important in an absolute improvement sense, was relatively unimportant as a contributing factor to the ERR, only about 2% of the ERR was due to health improvements.

2. The Chulband Medium Irrigation Project.

Figure 7 presents the Chulband benefit cost analysis in graphic form.

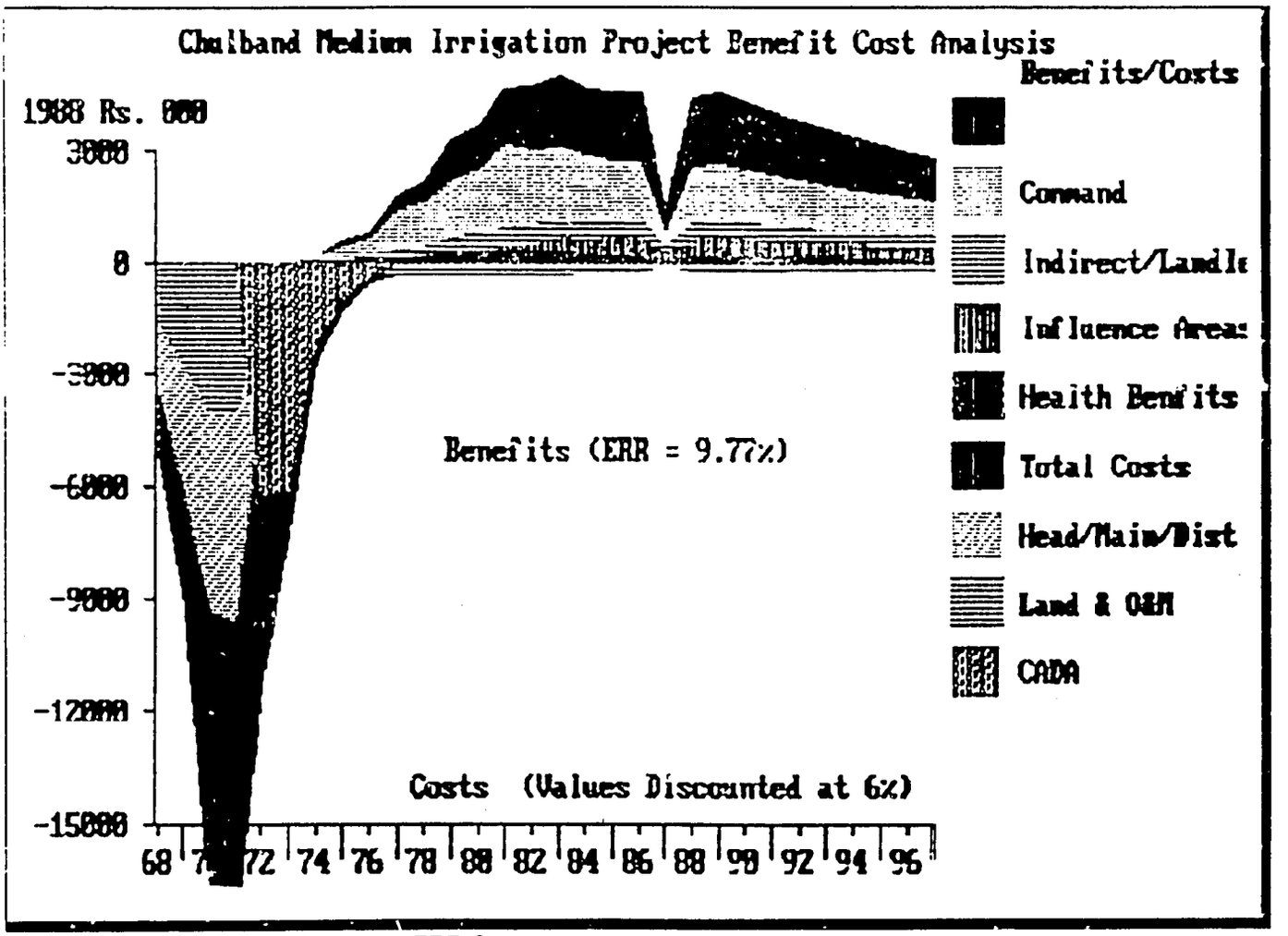

Figure 7: Chulband Benefit Cost & ERR Summary

The Chulband project is a medium project irrigating up to 3,000 hectares, mostly in Kharif paddy. There has been very little rabi irrigation with residual tank holdings being used for hot weather paddy. The tank is located in the Bhandara district which is in the assured rainfall agro-climatic region of Eastern Maharashtra.

Chulband has an estimated ERR of 9.7% which is well below the frequently targeted minimum rate of 12%. These benefit cost patterns and ERR are the logical conclusion of the above described situation. There has been essentially no crop diversification in the Chulband command. Paddy was essentially the sole crop before irrigation and it has persisted as the sole crop after. Yields and cropped areas have made reasonable sized increases but the incomes generated by these increases are overwhelmed by the costs of the system. Before raising the specter of escalating costs, it should be noted that Chulband does not present such a case, its costs appear to be inside an average range for medium projects.

The basic problem for Chulband as we assess it is not that its costs are too high, but simply that its benefits are impossibly low. Chulband appears to be an irrigation project without an income generating engine anywhere commensurate with its costs of construction. The almost total absence of rabi irrigation, and the apparently wasteful practice of holding water until hot weather for a relatively low value crop such as paddy add together to spell low performance.

Table IV: Chulband ERR Contributions by Benefit Type

Health	0.35
Indirect/Landless	2.16
Influence Areas	1.45
New Crops Wells	0.00
New Crops Canals	0.00
Foodgrains	5.81
Total ERR	9.77
Foodgrains ERR	5.81

The cost of hot weather water is relatively high when one accounts for evaporation losses. These higher costs may well be justified when it is used to "bridge" a high value perennial crop or produce a high value groundnut or vegetable crop, but it is unlikely that summer paddy would create the kinds of returns required to pay for hot weather water and Chulband's low ERR appears to confirm this concern.

The graph presented in Figures 7 & 8 for Chulband was discounted at 6% not 12% as was the case for Mula and Sidhanath. The reason for this alteration was purely presentational, but illustrates the low productivity of the Chulband project. When the graph was produced at a 12% discount rate, the negative reach of the costs exceeded the width of the computer forms used to print the graphs. Thus to obtain a graph for this report we had to either shrink the scale of benefits to the point that one could not distinguish any of the minor benefit categories or reduce the discount rate allowing the costs to correspondingly shrink and fit inside the computer form.

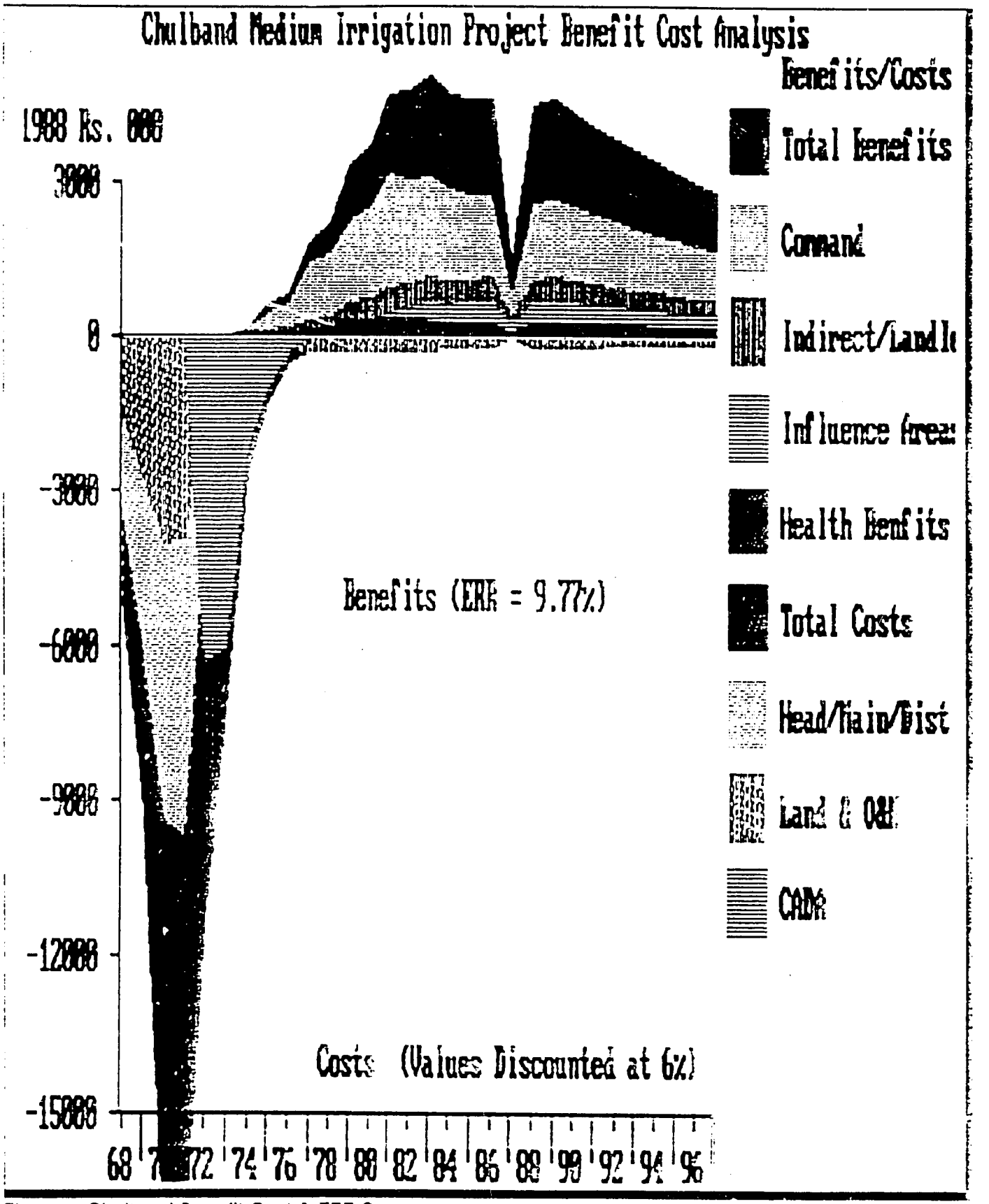

Figure 8: Chulband Benefit Cost & ERR Summary

3. Sidhanath Minor Irrigation Project

Sidhanath is a minor project located in the drought prone district of Sangli in South Western Maharasntra. The project was begun in 1974 and has been irrigating 100-200 hectares since 1980. The area actually irrigated has fallen far short of the hoped for 1,400 hectares which project planners thought could be irrigated by the system. There have also been problems of water logging in about 100 hectares of the command.

In spite of these problems the data suggest that Sidhanath has a very acceptable ERR of 15.9%. Figure 9 (enlarged in Figure 10) indicate that this is due largely to crop diversification both inside the command and on wells in the groundwater influence area.

A second reason for the relatively high ERR is the short time span involved from the start of construction to the beginning of benefits. Even though the benefits per hectare are about one third of those found in the Mula command, and nominal costs are higher, the shortness of time slice results in an ERR only one fourth less than Mula.

The importance of well development inside and outside the command is reflected in the fact that wells inside the command irrigate more land on the average than do canals, and crop incomes derived from new crops on these wells (largely recharged by the system) is the basic engine of the income benefits. Relative contributions of the various benefit types may be seen in Table I above. New crops accounted for roughly 90% of all direct benefits and a larger share of indirect ones. If Sidhanath were to have depended totally on its foodgrain yield and area increases it would have had an ERR of -1.88.

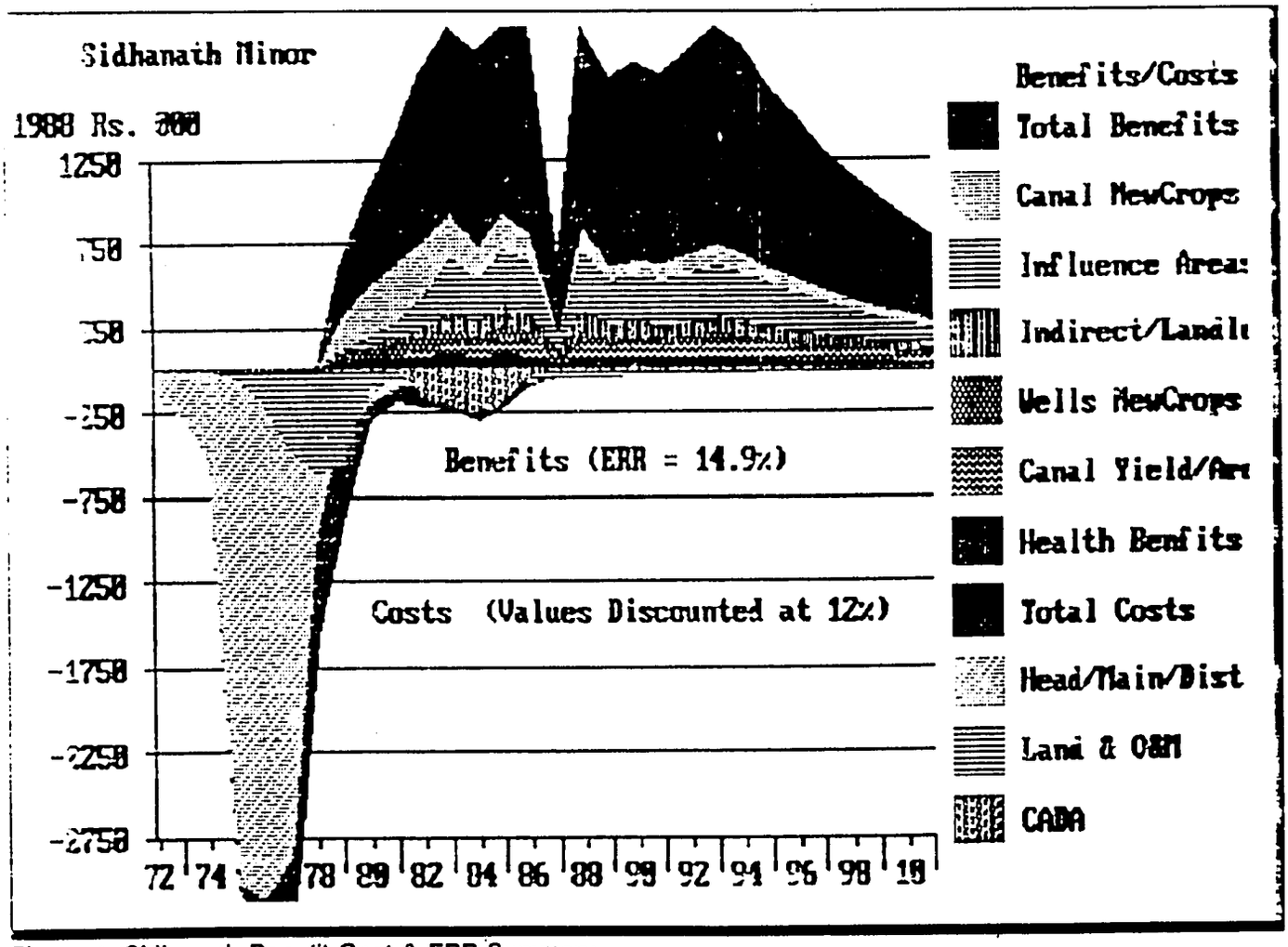

Figure 9: Sidhanath Benefit Cost & ERR Summary

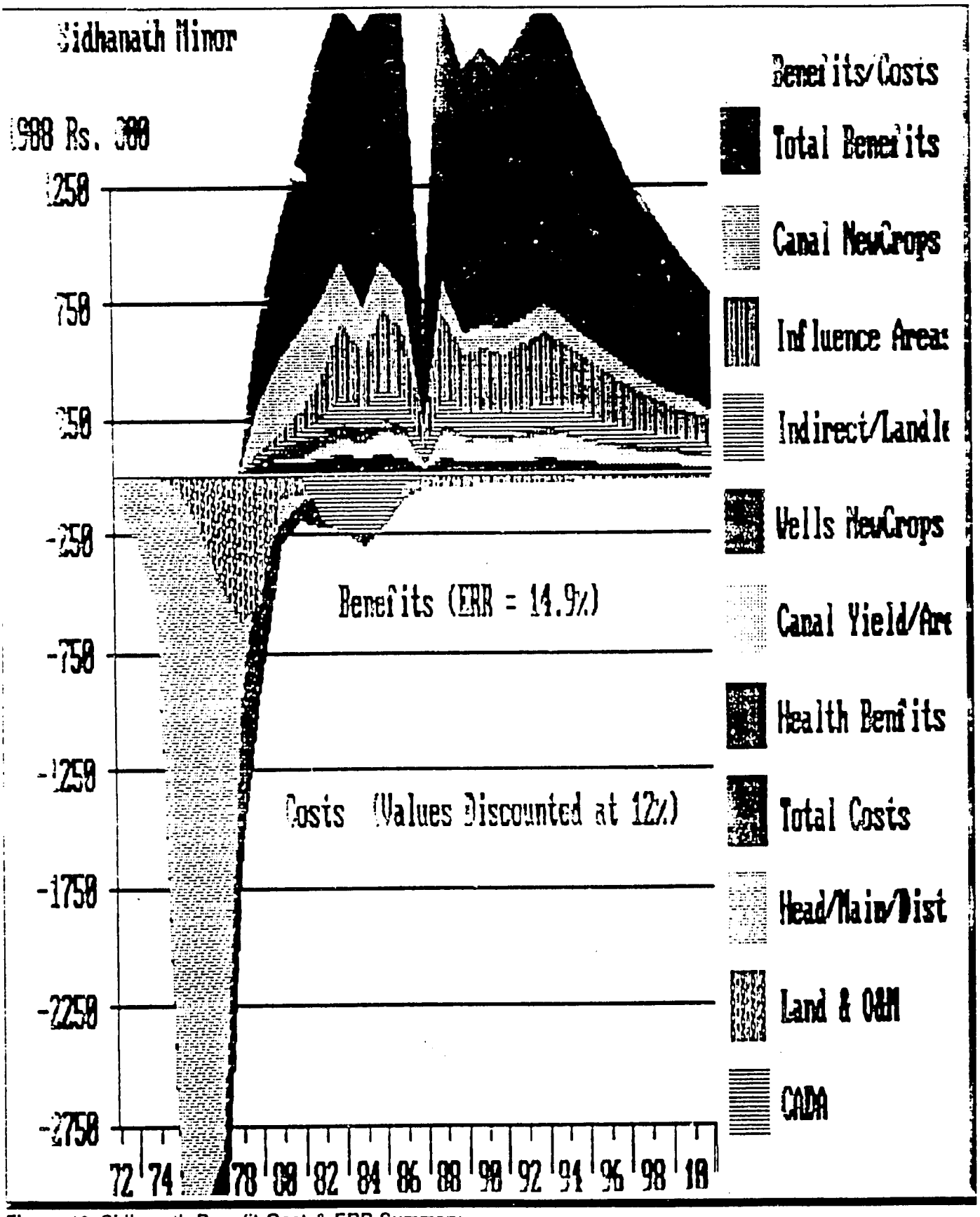

Figure 10: Sidhanath Benefit Cost & ERR Summary

C. Income Impact Evaluation

1. Mula Income Impact

Figure 11 indicates that the Mula project has been associated with an increase in income per hectare planted inside the command of over Rs. 12,000. Almost Rs. 10,000 of that increase has resulted from the introduction of new crops, with foodgrain yield increases accounting for the balance. Figure 12 shows these contributions to income improvement in percentage terms, new crops accounting for 81% of the increase, foodgrain yields 13% and foodgrain cropped area 5%.

Figure 11 also illustrates the relative comparison of farms inside the command with and without wells in the last two bars. There is some small difference but not enough to suggest any overall conclusions. Figure 13 outlines the relative contribution of wells and canals to overall income increases for command and influence area farms. Influence area farms made less than half the income improvement of command farms and largely from wells, though there was some increase due to lift influence area

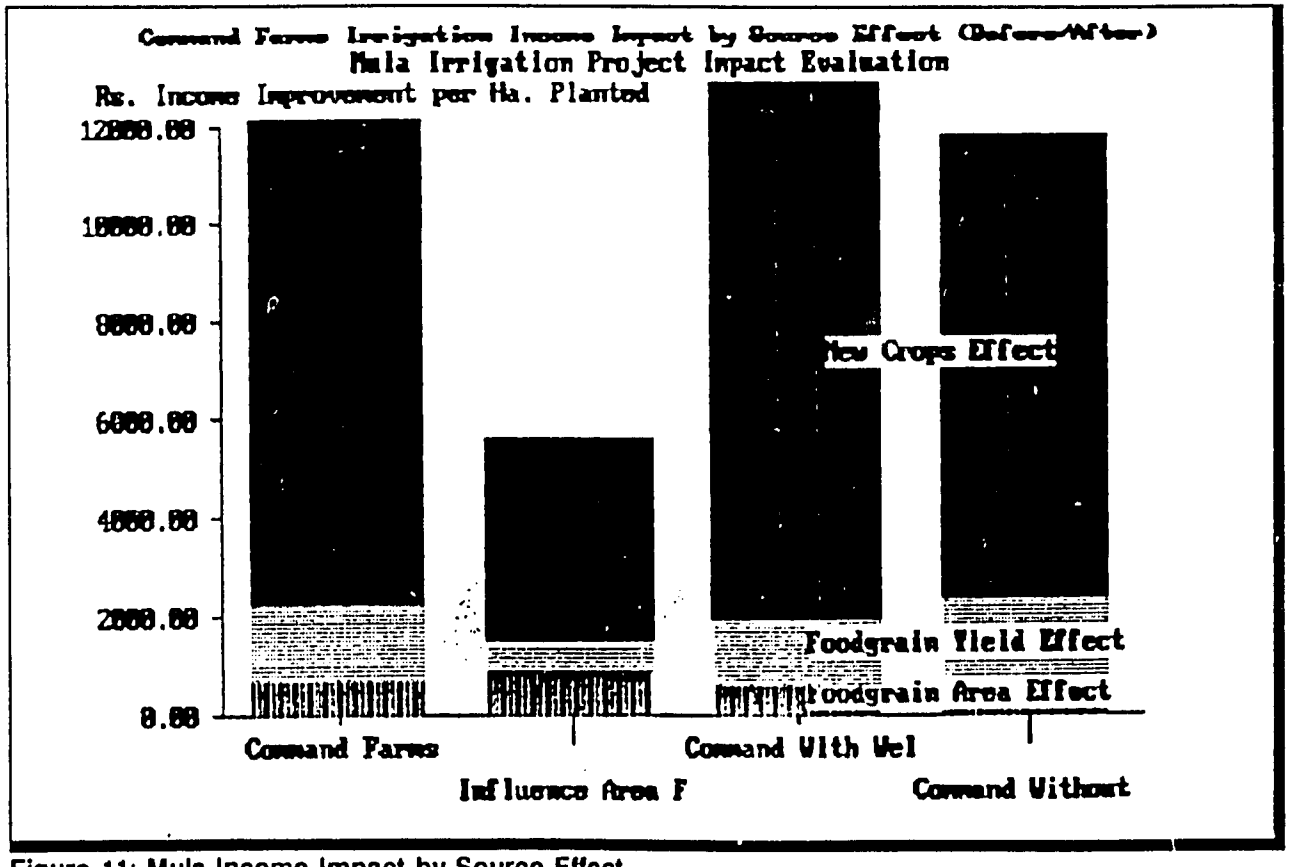

Figure 11: Mula Income Impact by Source Effect

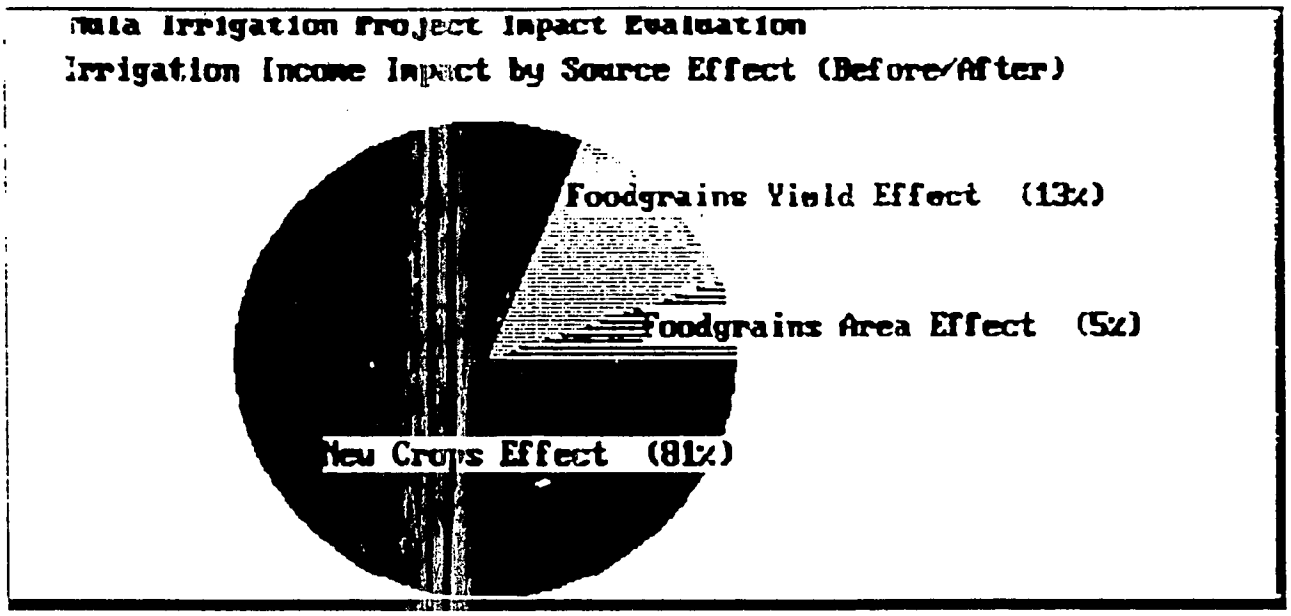

Figure 12: Mula: Percent of Income Impact by Source

improvements these were not nearly as large as would be expected from the large lift influence area associated with the Mula project. It is interesting to note in Figure 13 that those command farms with wells depend on them for more than half of their total income improvement.

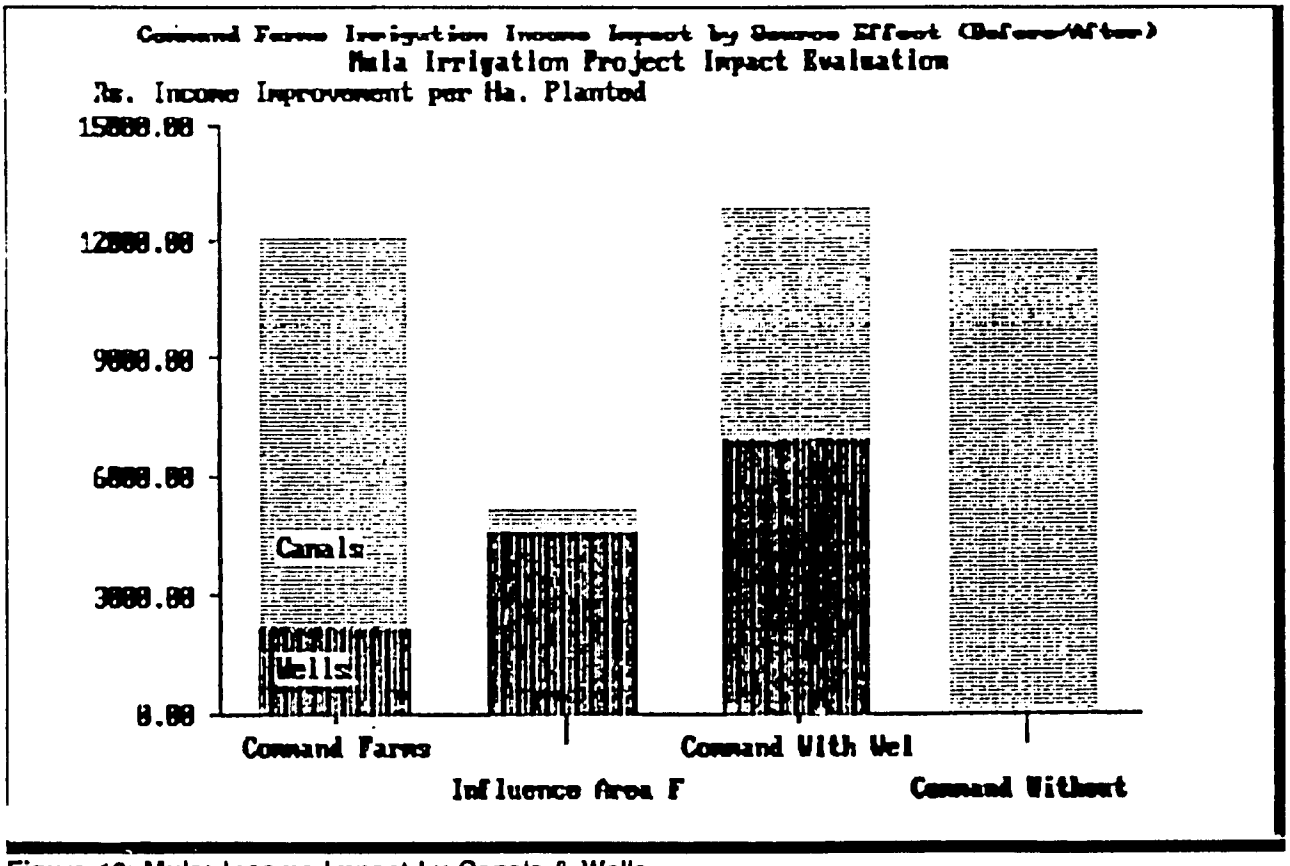

Figure 13: Mula: Income Impact by Canals & Wells

Figure 14 presents a somewhat complicated cross-sectional control group comparison to assess the relative income impact performance of the Mula command in a good year (1988-89) with a drought year (87-88). The first bar in each comparison represents the difference in income per hectare planted between a test group and a comparison or control group in each of these years. It should be noted that the comparison is not in family income or farm income but rather in per hectare planted income.

Command farm income per hectare planted minus control farm income was substantial in both the bad and good year, but the difference was much greater between the two groups in the bad year. A

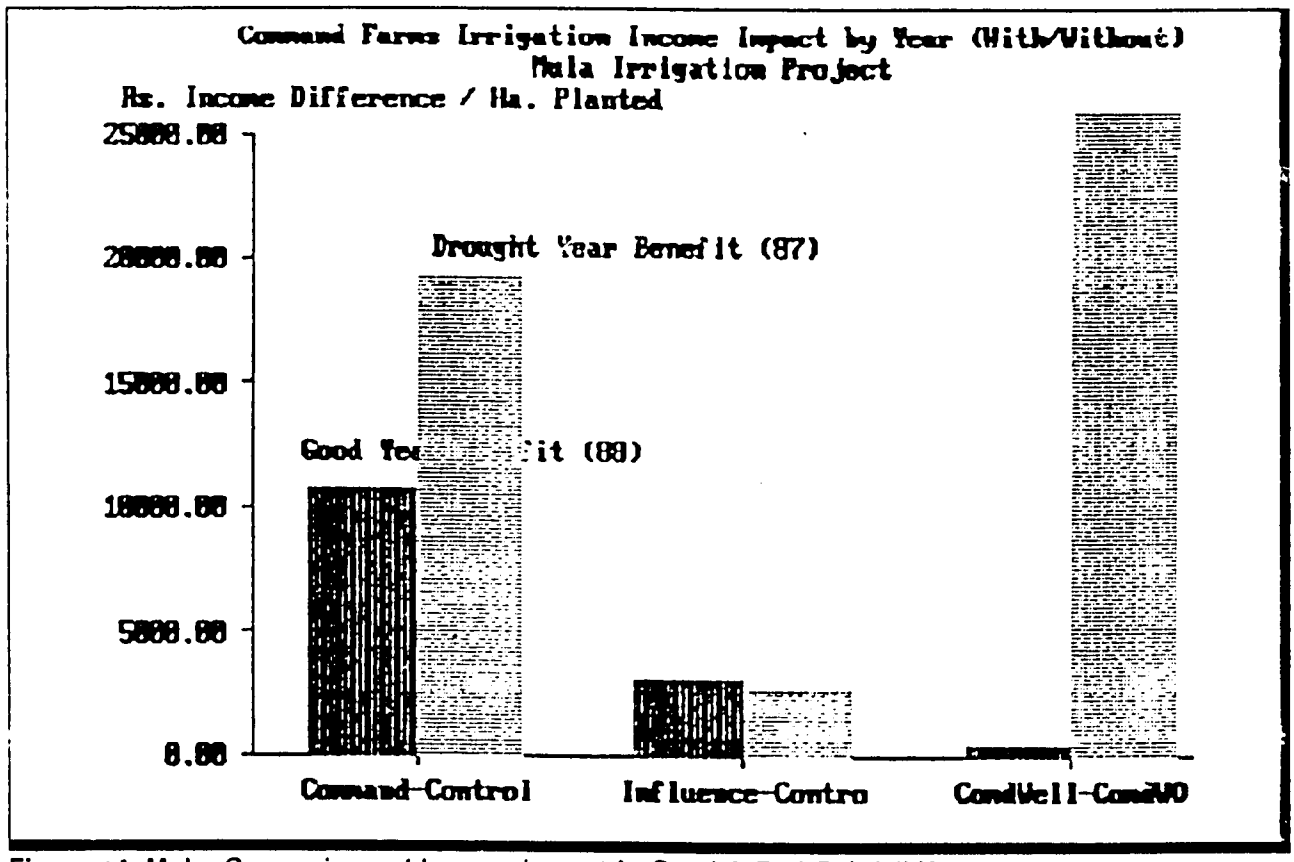

Figure 14: Mula: Comparison of Income Impact in Good & Bad Rainfall Years

review of the underlying data suggest the reasons for this substantial difference in relative performance. The control group farms must make planting decisions before the rainfall year is known to be good or bad and are thus locked into large costs in a bad year which cannot be avoided. Irrigated farmers may wait for much of their investment in planting until the status of the rain year is known and hence may reduce planting risk to accord with the sustainable area they can hope to irrigate.

2. Chulband Income Impact Evaluation

The total income impact of the Chulband project on command farms was approximately Rs. 1,100 per hectare planted. The mono-culture origin of this increase and the lack of well irrigation mean that this increase came essentially from improved paddy yields in Kharif and extended paddy area and yields during hot weather. This pattern is so simple that no detailed graphic analysis is necessary. It is important to note that the level of benefits produced by Chulband per hectare planted was less than 10% of that achieved by the Mula project and less than one fourth that of the minor project Sidhanath.

3. Sidhanath Income Impact Evaluation.

Figure 15 presents the income impact of the Sidhanath project. Impacts inside the command improved by just over Rs. 4,000 per hectare planted with half of direct impacts coming from foodgrain area effect. Major gains were made in the influence area of nearly

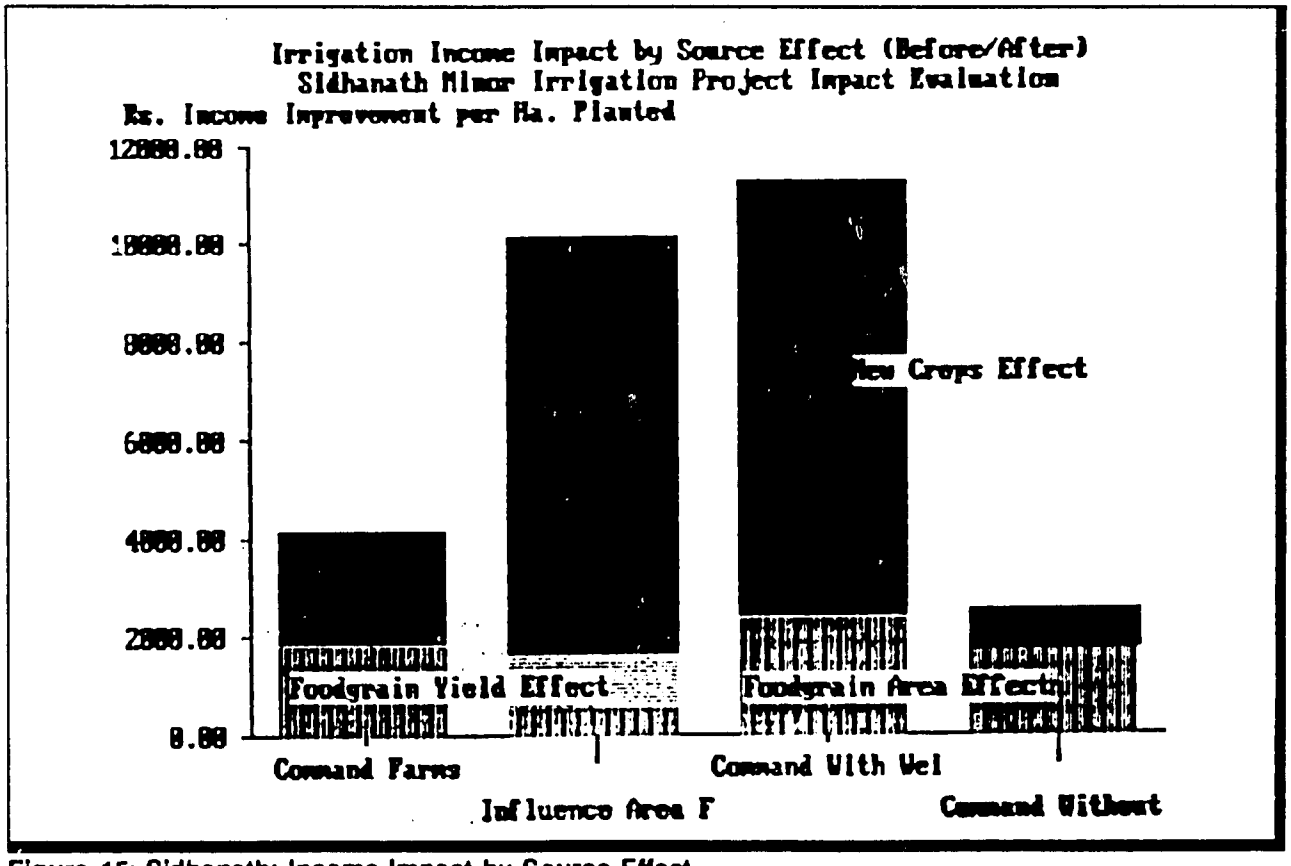

Figure 15: Sidhanath: Income Impact by Source Effect

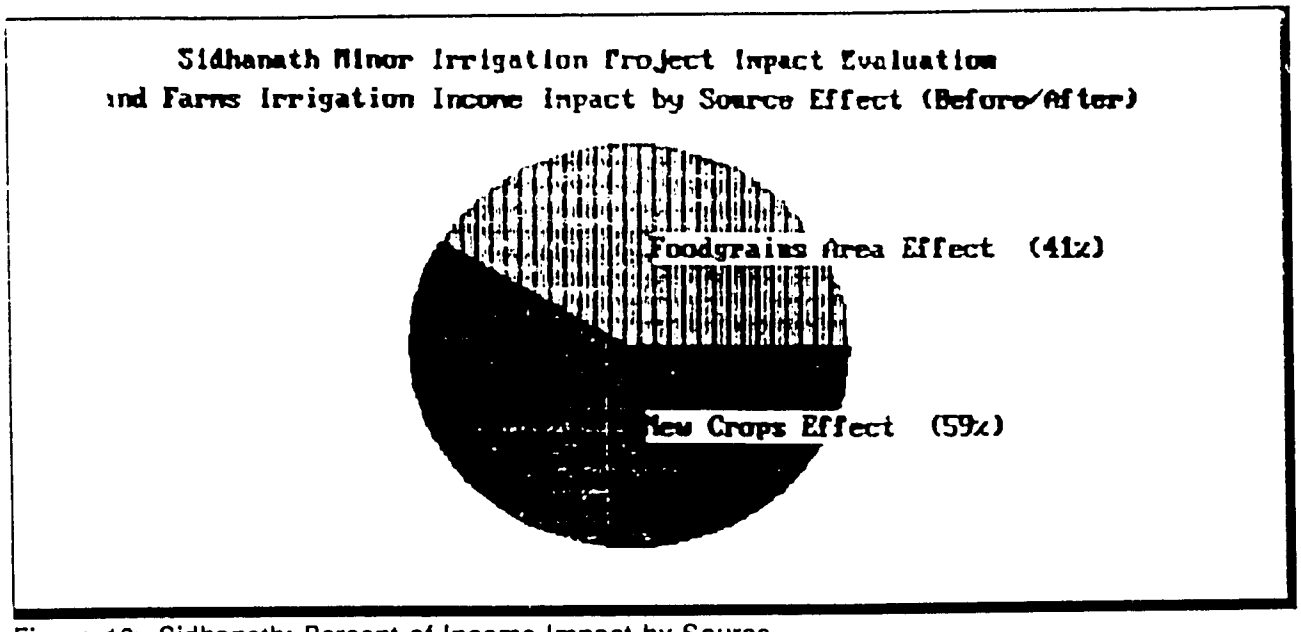

Figure 16: Sidhanath: Percent of Income Impact by Source

Rs. 10,000 per hectare underscoring the importance of wells and new crops on wells to the overall performance of the project. Figure 17 illustrates this point by showing that a few high performance farms inside the command with wells are carrying the others.

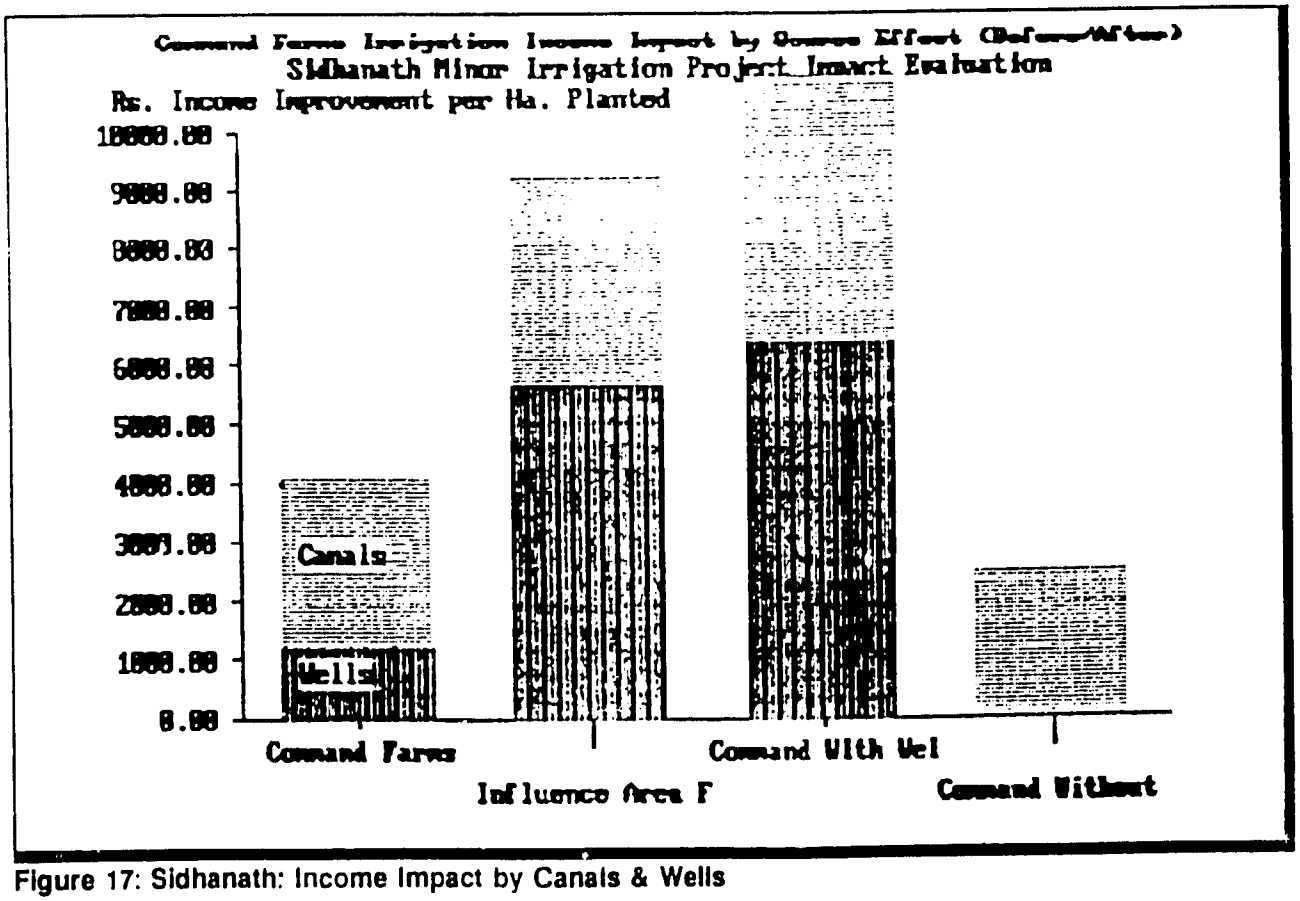

Figure 17: Sidhanath: Income Impact by Canals & Wells

D. Employment Impact Evaluation

1. Mula Employment Impact

Figures 18-20 outline the employment impact of the Mula project in terms of the numbers of person days of increased employment per hectare planted. Figure 18 indicates that the impact on farms in the command is over 100 persons days of increased labor per hectare planted. Influence area farms increased employment by roughly 40 person days per hectare. The sizeable difference between command farms with wells and those without may be seen both Figures 18 and 19. Employment improvement can be seen in Figure 18 to depend even more completely than income on crop diversification.

Figure 20 assesses employment impacts of irrigation in the Mula for good and drought years. Drougnt year differences like income are stronger than good year differences and likely for the same reasons explained above.

Employment impacts in influence areas are much weaker than inside the command and the difference between performance in good and drought years is essentially nil. This suggests the import level of drought defense which exists inside a command.

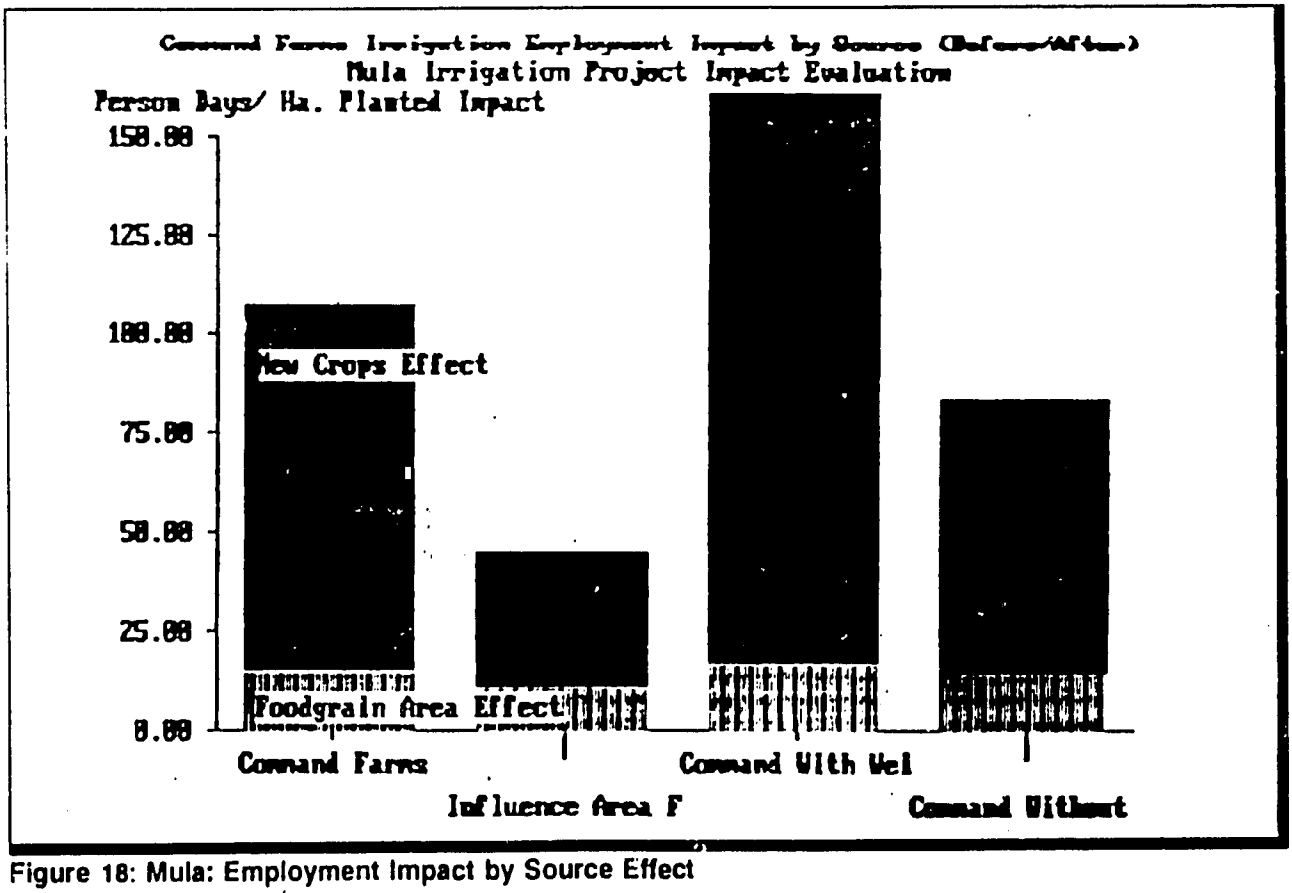

Figure 18: Mula: Employment Impact by Source Effect

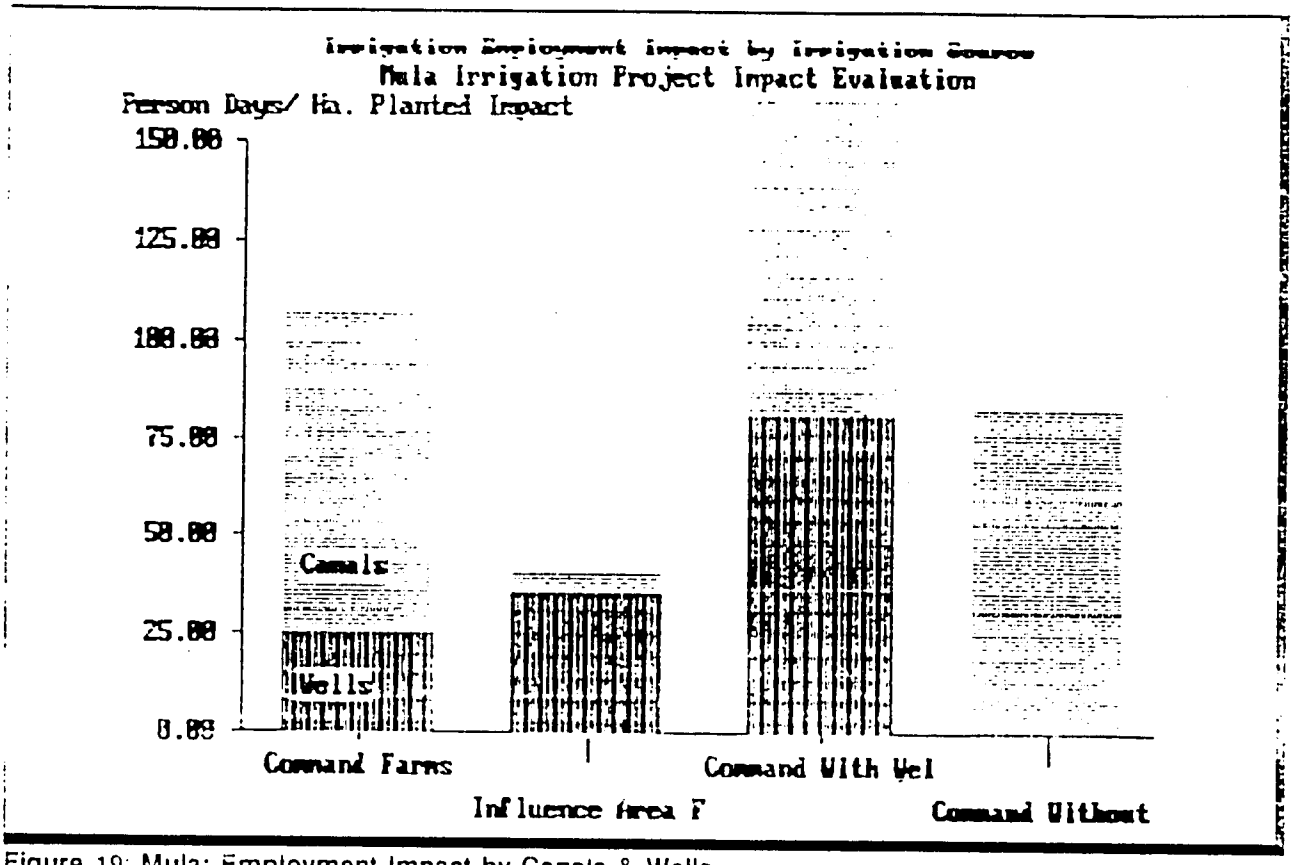

Figure 19: Mula: Employment Impact by Canals & Wells

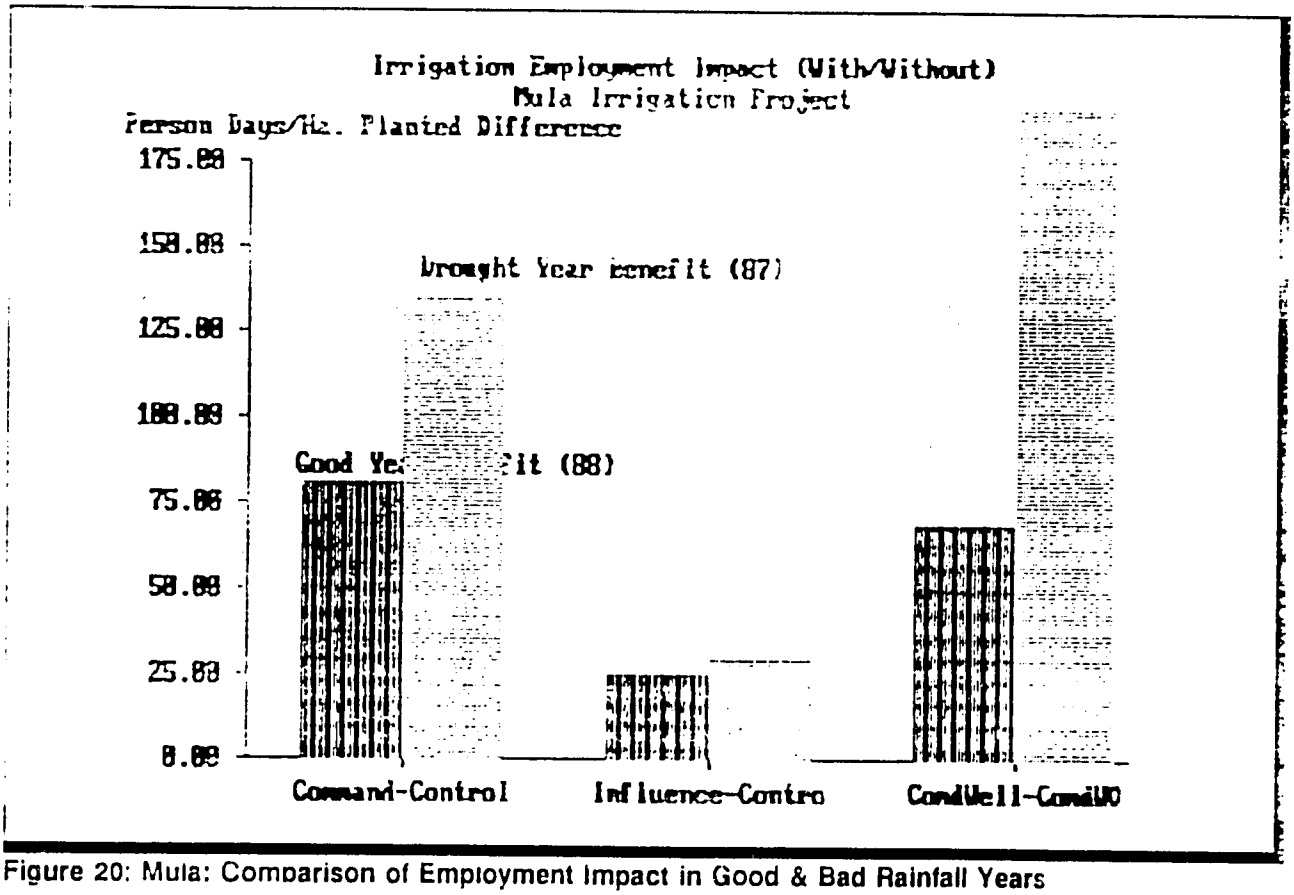

Figure 20: Mula: Comparison of Employment Impact in Good & Bad Rainfall Years

2. Sidhanath Employment Impacts

Figures 21-23 present the employment impact of the Sidhanath project. Figure 21 indicates that the overall level of impact is roughly 35 person days per hectare planted in the command and 30 days in the influence area. There is a substantial difference in the employment impact of farms in the command with and without wells. In contrast to the Mula command where almost all employment impacts derived from new crop diversification, in Sidhanath most employment impact inside the command came from foodgrains area cropped increases. In the influence area, however, the opposite was true, almost all employment impacts resulted from new crops.

Figure 22 indicates the strong employment impact of well irrigation inside the command, and also the heavy dependance of the smaller employment generated outside the command on recharged wells.

Figure 23 suggests that the higher variability of water supply in a minor tank fails to afford the kind of drought year protection and defense afforded by a major project like the Mula.

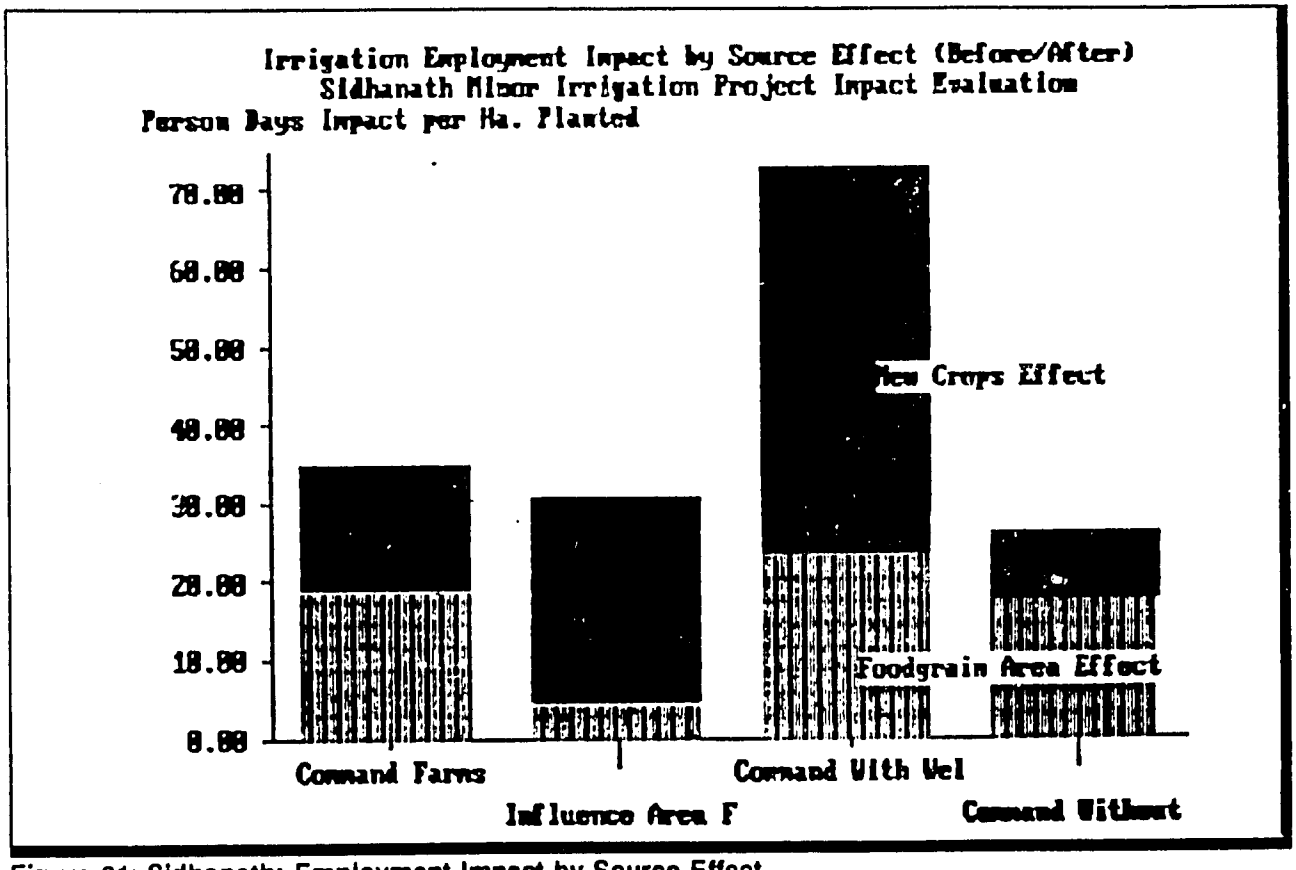

Figure 21: Sidhanath: Employment Impact by Source Effect

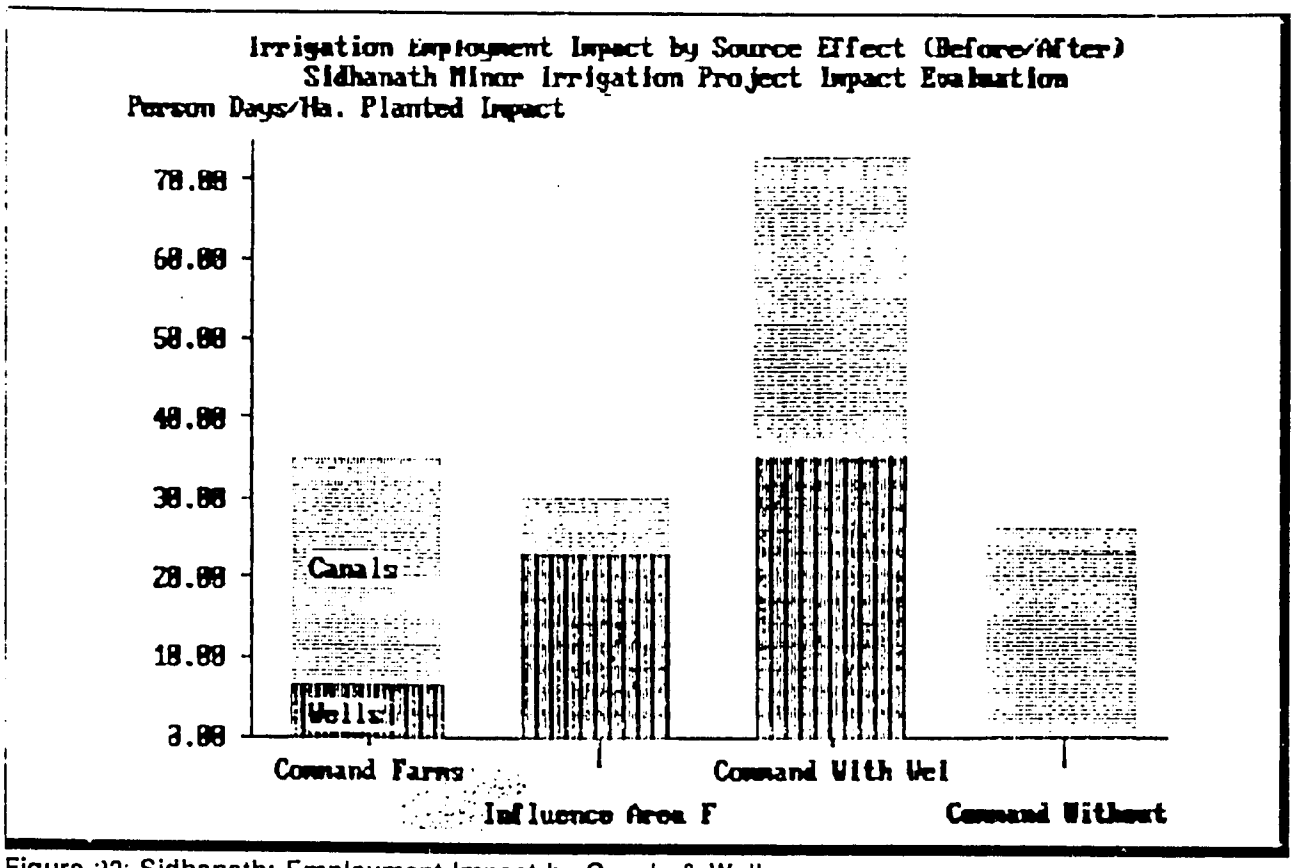

Figure 22: Sidhanath: Employment Impact by Canals & Wells

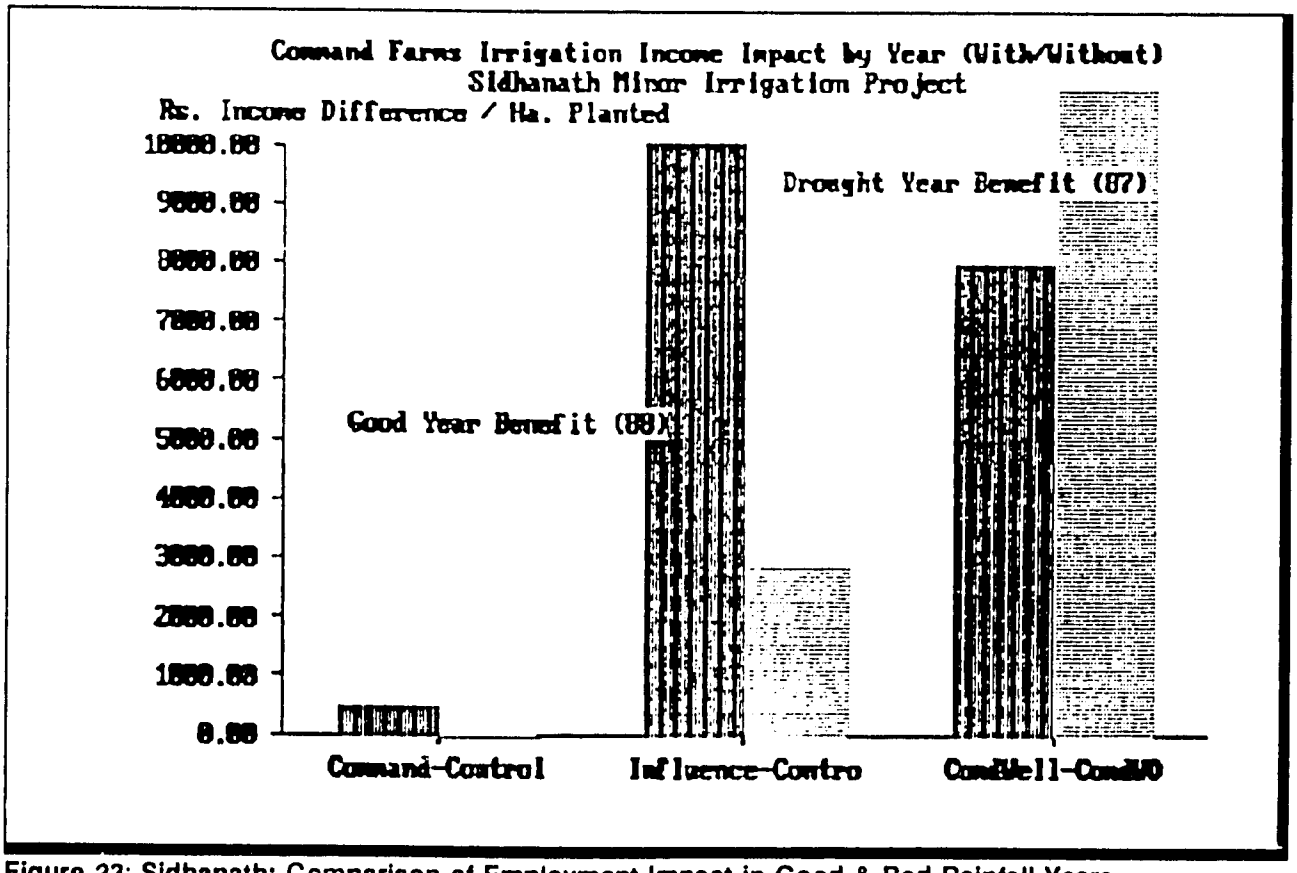

Figure 23: Sidhanath: Comparison of Employment Impact in Good & Bad Rainfall Years

F. Health Impact

1. Mula Health Impacts

Figures 24-27 present the Rapid Appraisal survey data on health impacts in the Mula project. Health impacts are estimated in the rapid appraisal system in terms of the number of work days lost to illness. These figures suggest that two somewhat contradictory effects are at work in the Mula project area related to water and irrigation.

Irrigation Effect> > When the with and without groups are combined into a weighted average, Figure 24 exhibits a consistent pattern of sharply reduced illness rates for adult males after the introduction of irrigation. This reduction is by more than half from roughly 20 days to less than 8, or a gross savings of about 12 days. During that same period the control group made only a slight improvement of about 1.5 days savings. By netting this control group improvement from the gross difference for the command group we get a net savings of

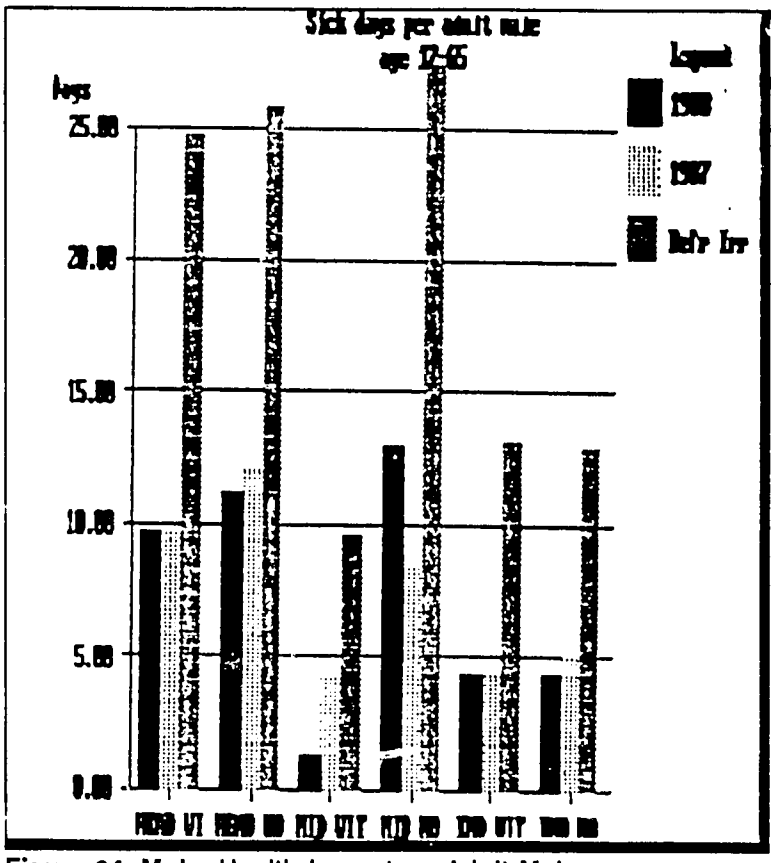

Figure 24: Mula: Health Impact on Adult Males

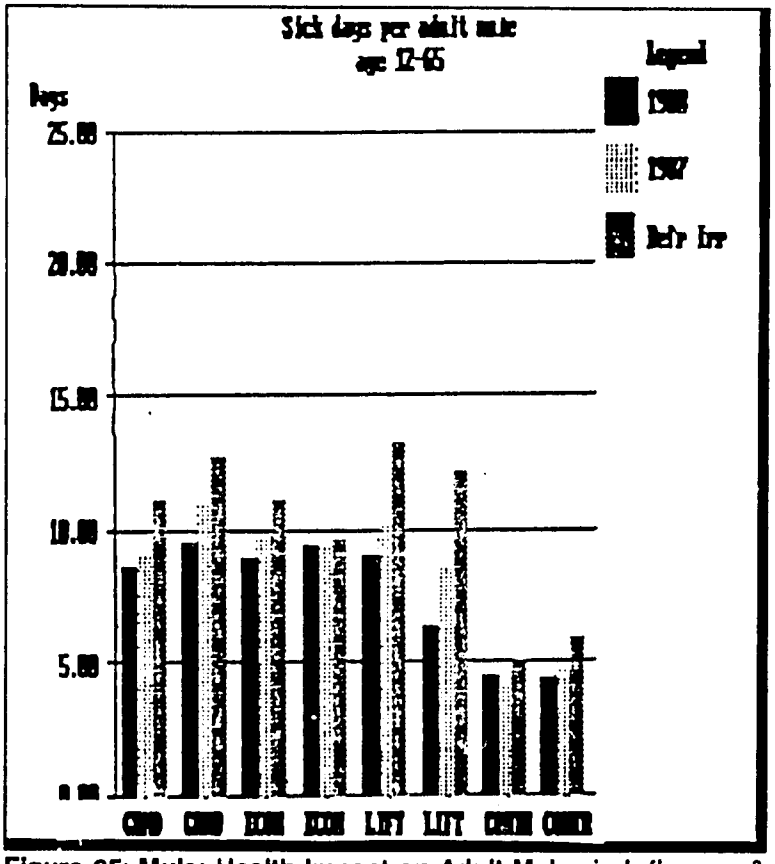

Figure 25: Mula: Health Impact on Adult Males in Influence & Control Groups

approximately 10.5 days.

"Wet Lands Effect">> There also appears to be a negative impact of proximity to water which existed both before and after the introduction of irrigation. This can be noted before irrigation by comparing the average days ill for the command groups of about 16 days with the control group of 6. Without more detailed data on the incidence of malaria in these illnesses it is impossible to determine with certainty these effects. But the trends are sufficiently strong to suggest that this difference before the introduction of irrigation was due to malaria and that the command farms were located before irrigation closer than the control groups to perennial streams and standing water.

What is important for our purposes to note is that irrigation substantially reduces illness AND significantly narrows the gap between the lower illness rates of

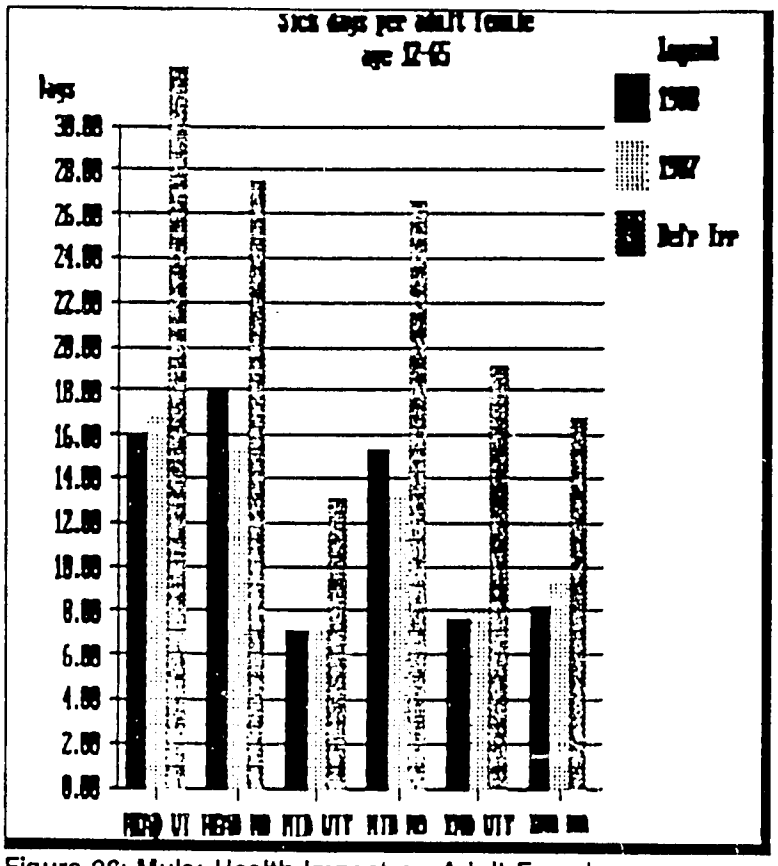

Figure 26: Mula: Health Impact on Adult Females

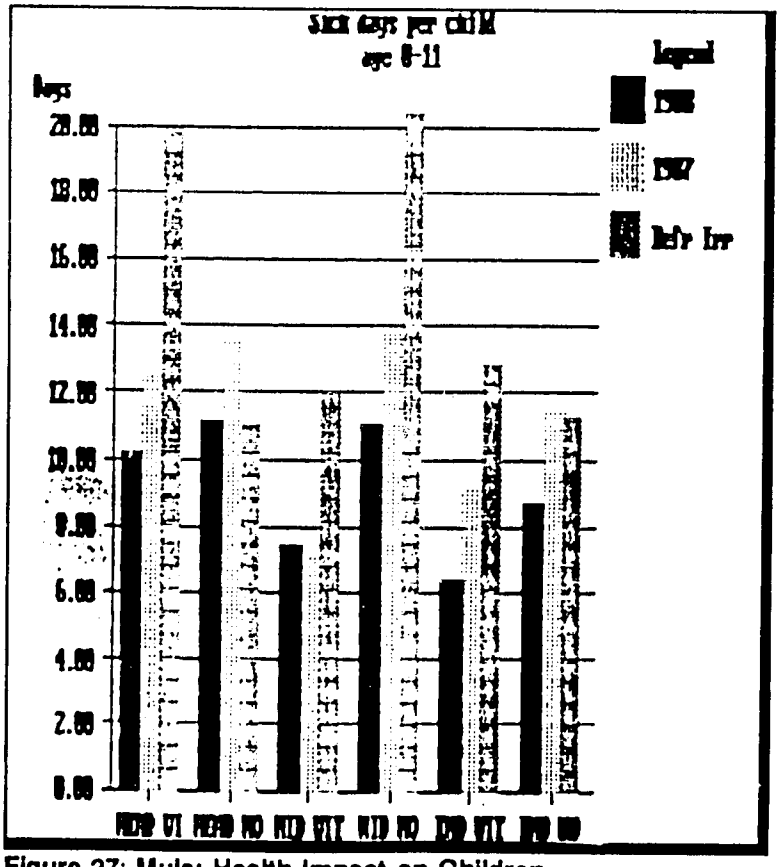

Figure 27: Mula: Health Impact on Children

those living near to and far from standing water. There has been considerable concern that irrigation, since it involves increasing standing water areas, might increase malaria. When accompanied by the type of control measures used in the Mula command this appears not to be the case, on the contrary, health levels improve significantly.

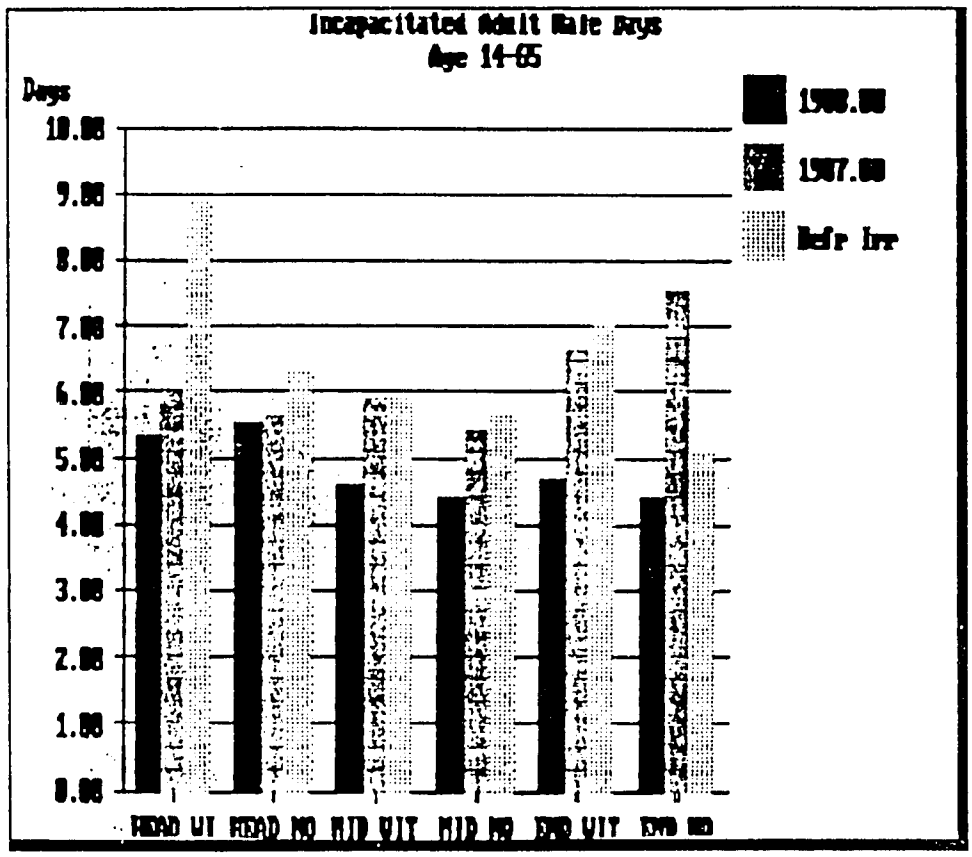

Figure 28: Chulband: Health Impact on Adult Males in Command

2. Chulband Health Impacts

Figures 28 and 29 present a similar analysis of health impacts in the Chulband project. The data for Chulband indicate only a small part of the positive impact found in the Mula command. Health has improved

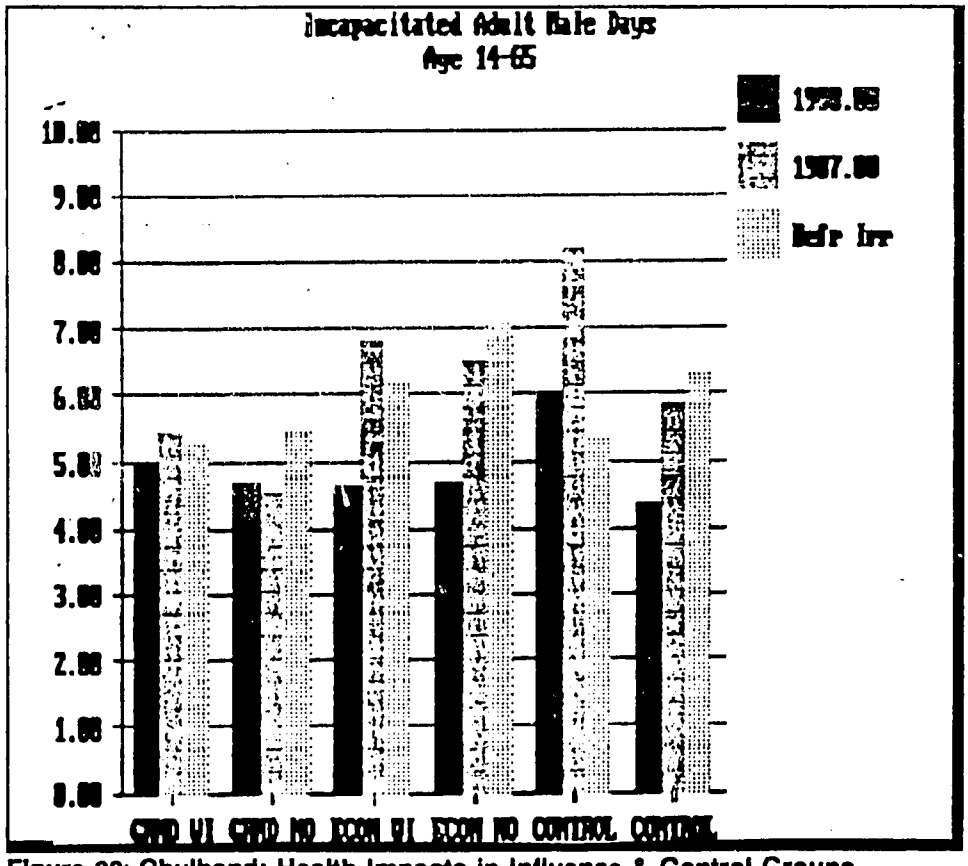

Figure 29: Chulband: Health Impacts in Influence & Control Groups

after irrigation, but control groups also made significant improvements over the same period. Thus when control group improvements are netted from gross command farm improvement, there is little net benefit.

Figure 30 presents the difference in access distance to drinking water for the Chulband families and control groups. All groups have made significant improvement during roughly the same period which suggests little or no irrigation impact.

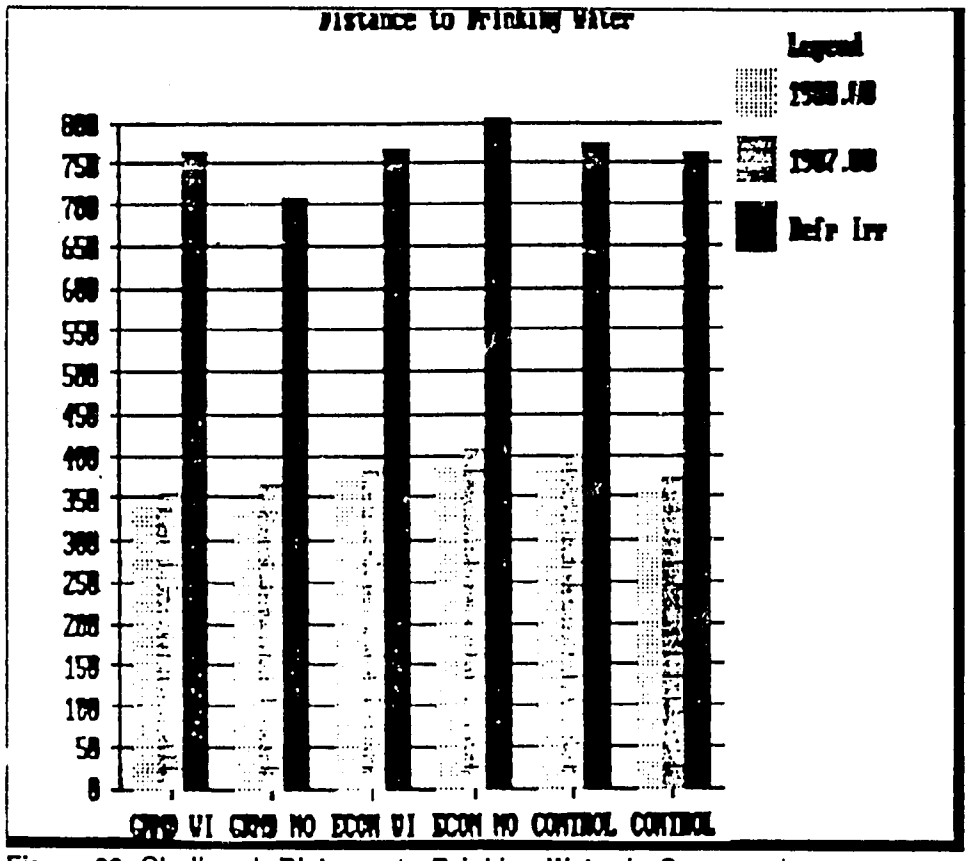

Figure 30: Chulband: Distance to Drinking Water in Command

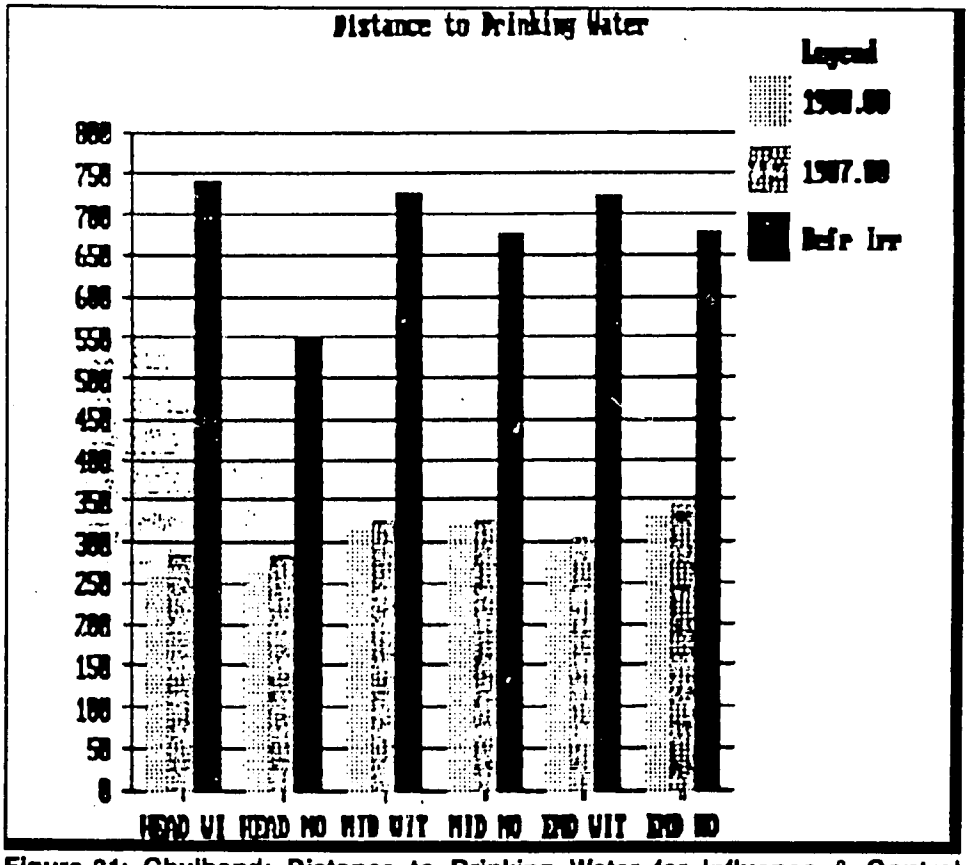

Figure 31: Chulband: Distance to Drinking Water for Influence & Control Groups

Figures 32 & 33 examine the distance issue with reference to washing water. While command farms have a closer access after irrigation, that gross improvement is not significantly different from the improvement made by control group farms and families during the same period so there appears to be no net impact from irrigation.

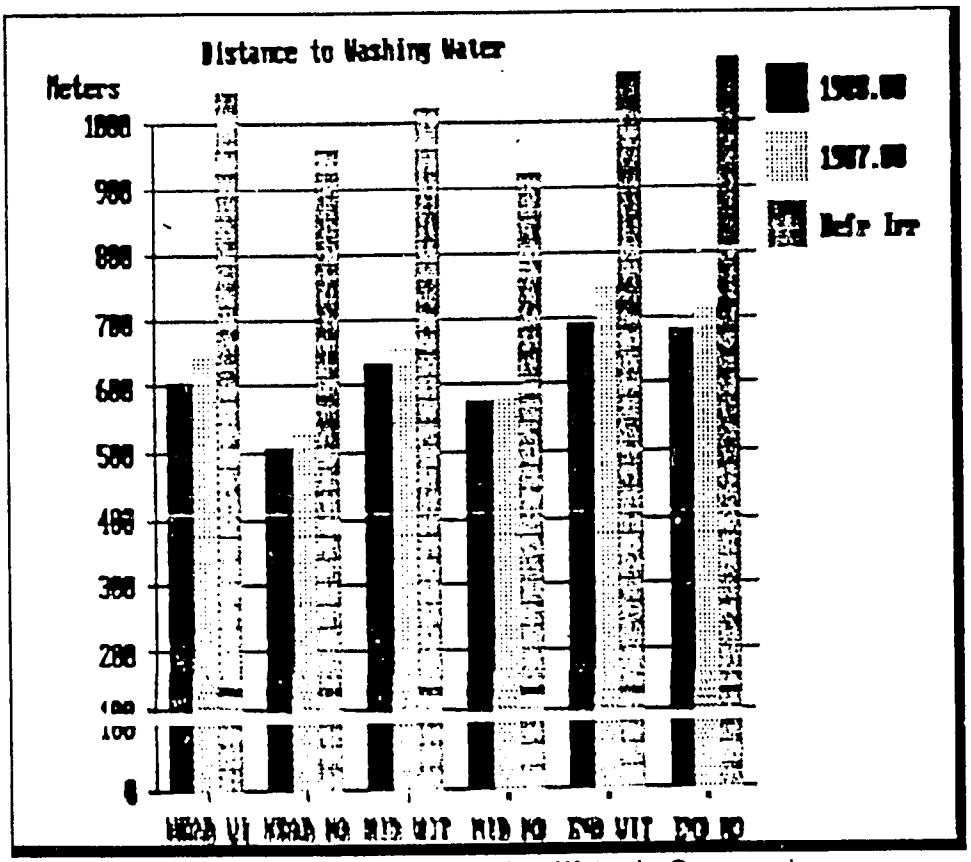

Figure 32: Chulband: Distance to Washing Water in Command

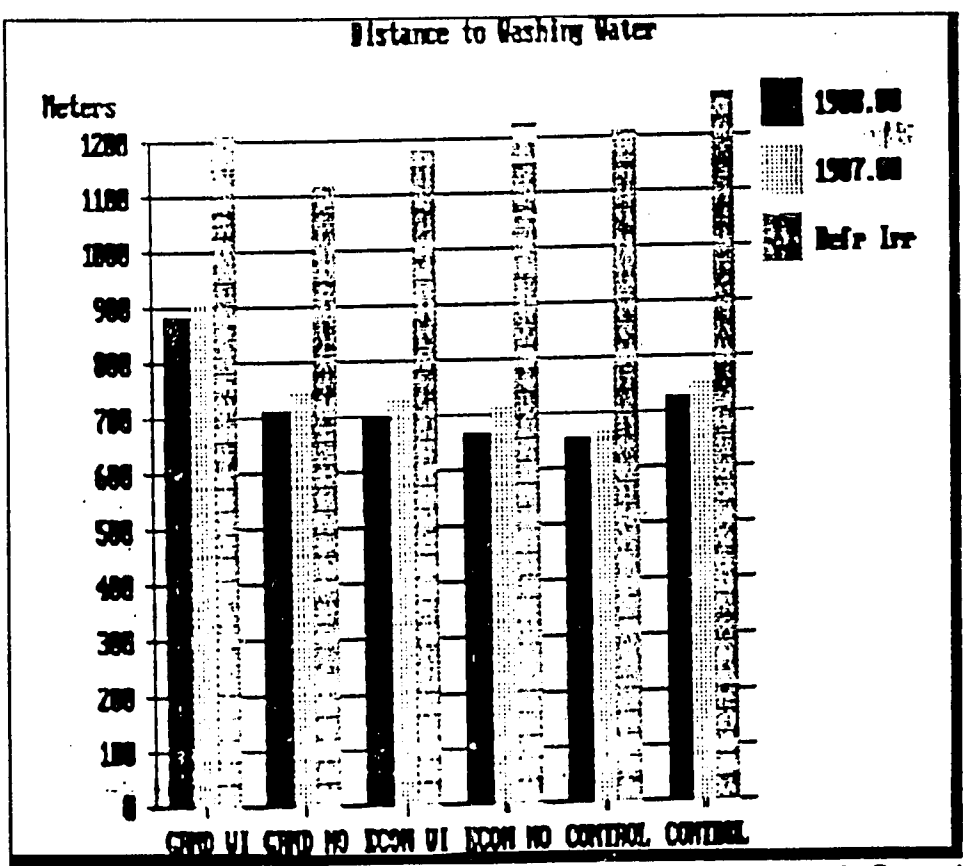

Figure 33: Chulband: Distance to Washing Water for Influence & Control Groups

3. Sidhanath

Health Impacts

Figures 34-38 present the health impacts data for the Sidhanath project.

A review of figures 34, (when appropriately combined for weighted averages) suggests a significant impact of irrigation similar in general pattern, but lesser in magnitude than the Mula.

The command group make reductions by roughly half, while control groups improve only slightly. However the absolute numbers are significantly less than Mula. This is consistent with the malaria hypothesis since all groups in the Sidhanath area were much "drier" before

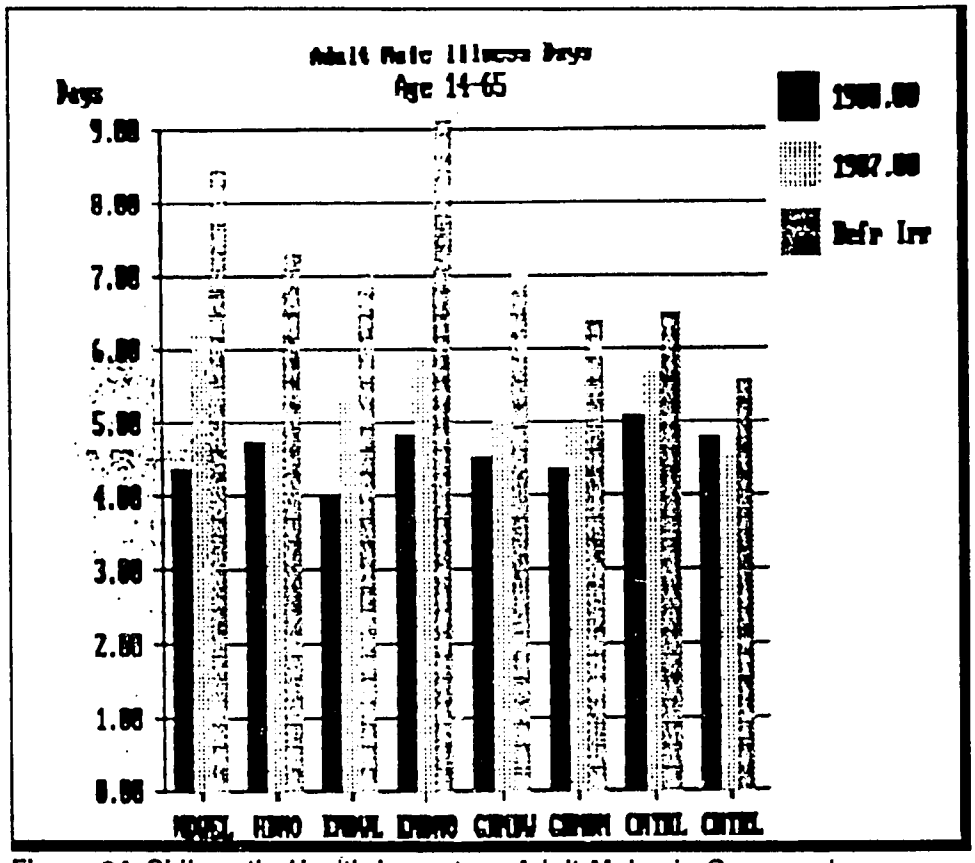

Figure 34: Sidhanath: Health Impact on Adult Males in Command

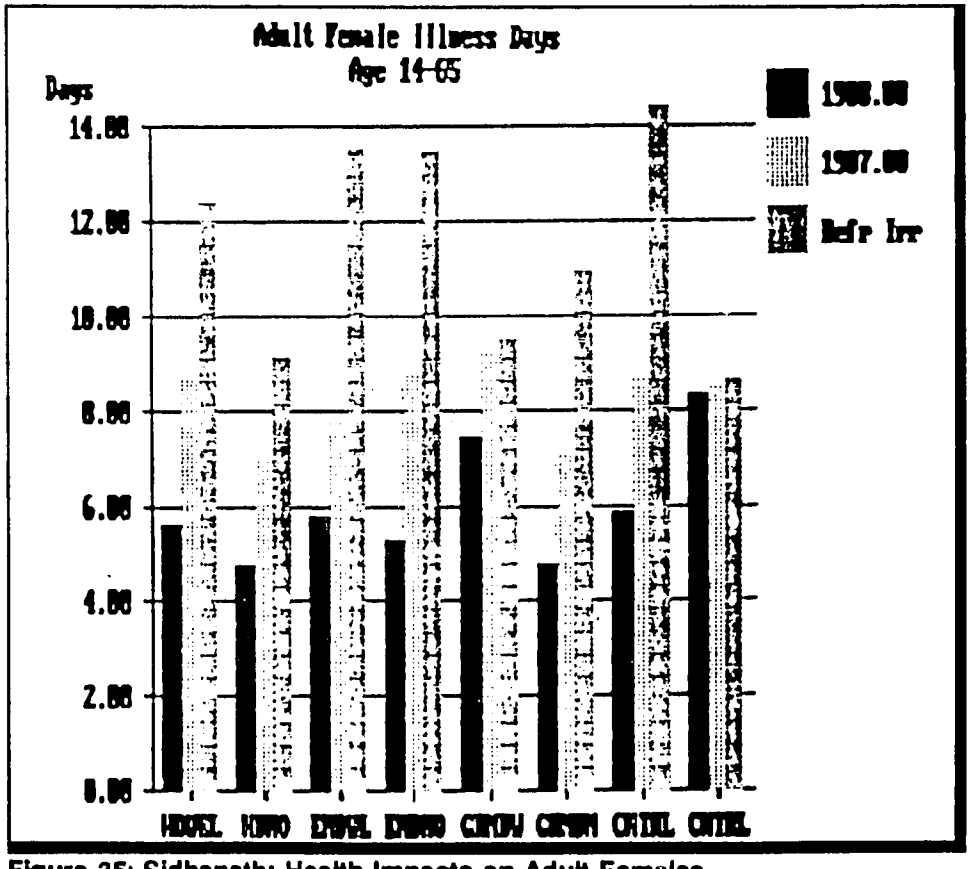

Figure 35: Sidhanath: Health Impacts on Adult Females

irrigation than comparable groups in the Mula command area since there were no perennial rivers and streams.

Figures 37 and 38 present data on access distance to drinking and washing water before and after irrigation. There is a slignt net improvement for irrigated farms during the period, but the difference is not large since control group farms also made sizeable improvement.

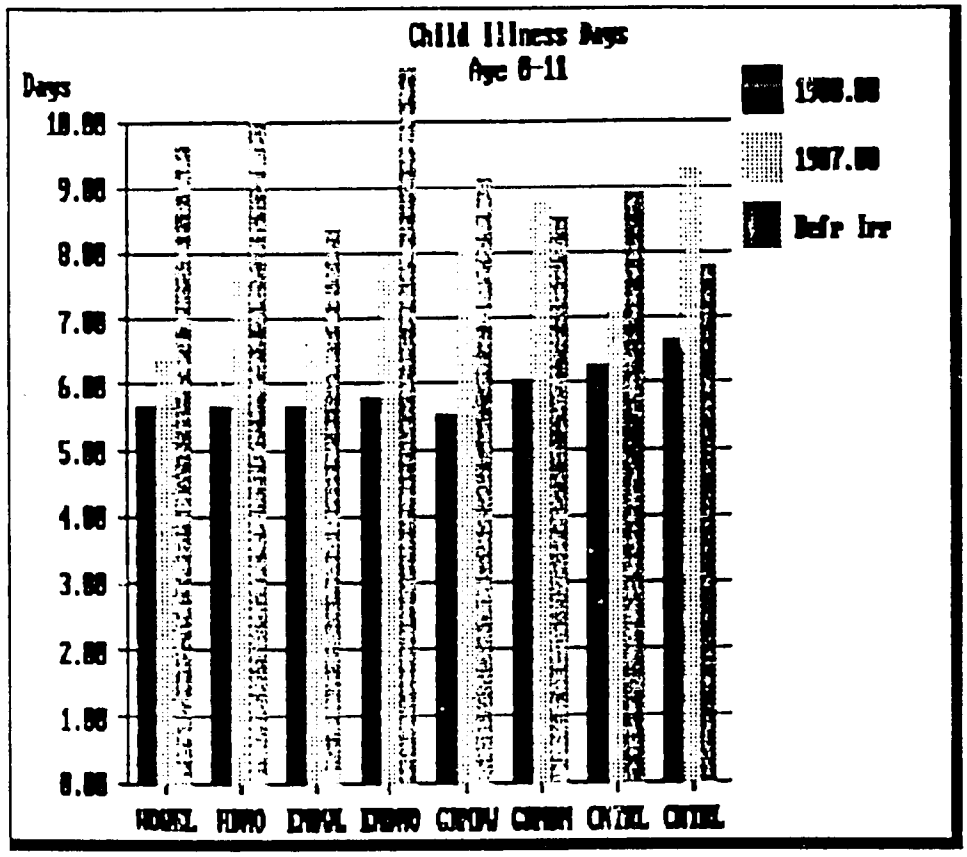

Figure 36: Chulband: Health Impact on Children

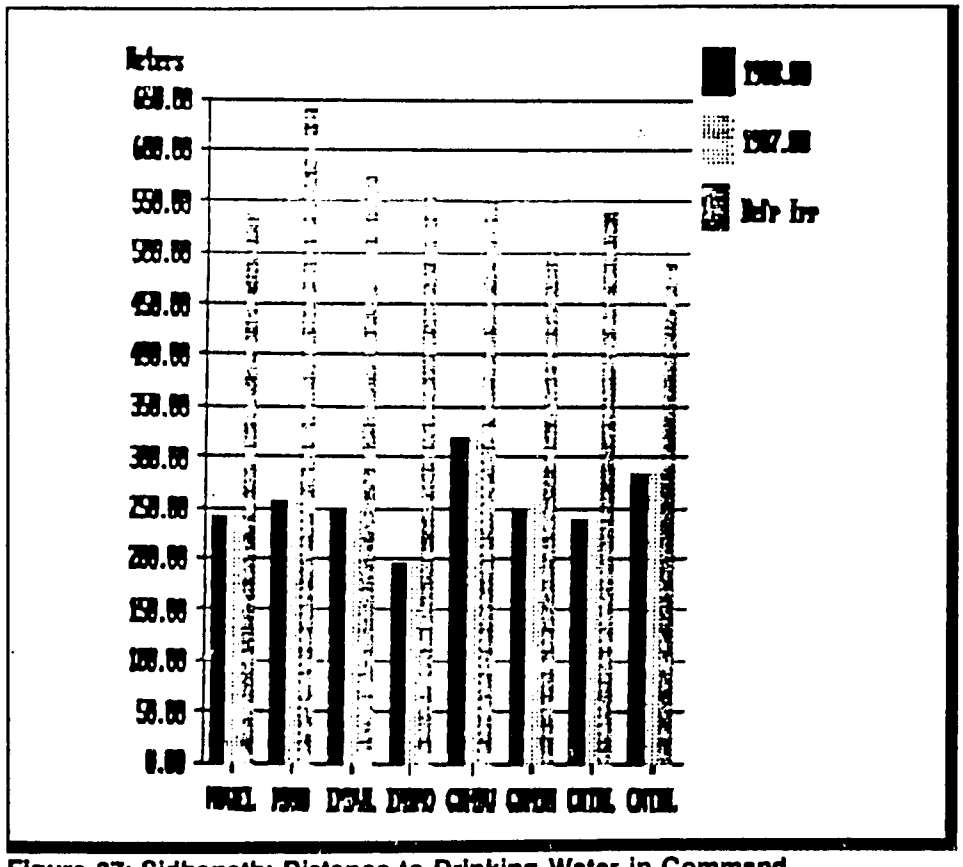

Figure 37: Sidhanath: Distance to Drinking Water in Command

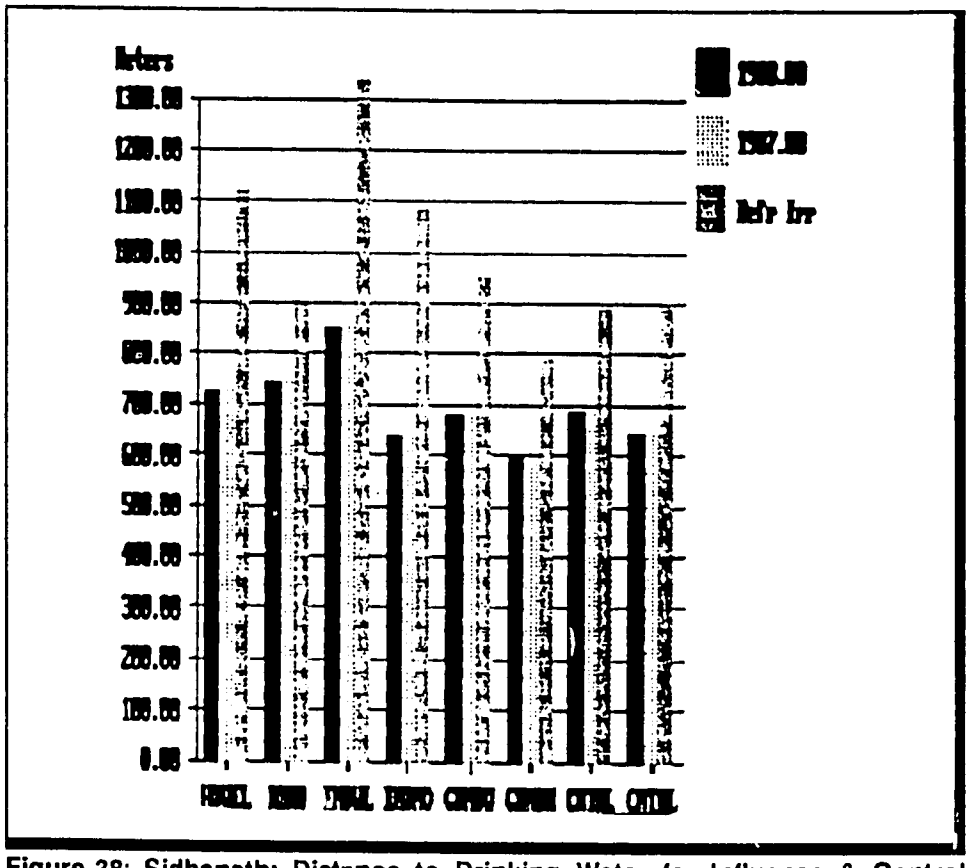

Figure 38: Sidhanath: Distance to Drinking Water for Influence & Control Groups