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IRRIGATION SECTOR STRATEGY REVIEW

APPENDICES
VOLUME II

INDIA

USAID

WATER MANAGEMENT SYNTHESIS II PROJECT

WMS REPORT 35

IRRIGATION SECTOR STRATEGY REVIEW
USAID/INDIA

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VOLUME II

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PREFACE

This study was conducted as part of the Water Management Synthesis II Project, a program funded and assisted by the United States Agency for International Development through the Consortium for International Development. Utah State University, Colorado State University and Cornell University serve as co-lead universities for the Project.

The key objective is to provide services in irrigated regions of the world for improving water management practices in the design and operation of existing and future irrigation projects and give guidance to USAID for selecting and implementing development options and investment strategies.

For more information about the Project and any of its services, contact the Water Management Synthesis II Project.

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FOREWORD

This Irrigation Sector Evaluation and Strategy Review was conducted at the request of USAID/India through a "buy-in" arrangement with the Water Management Synthesis II Project (WMSP). USAID India's program in irrigation began in 1978 and now represents a cumulative commitment of $315 million. The Mission's strategy has been continuously reviewed in its annual CDSS (Country Development Strategy Statement), but these are "in-house" exercises. The Mission and Asia Bureau of AID/W both felt that an in-depth review by an outside group during 1984-85 would be very desirable as one important input for future strategy planning, especially considering the size of the program, the complexity of the irrigation sector and the implied long-term commitment.

AID and WMSP agreed that the three principals would be solely responsible for the evaluation. The principals were supported by three associates, one of whom had been involved in the development of the present irrigation program, one who had past involvement with general USAID/India strategy and a social scientist with considerable previous Indian experience.

The studies were conducted in India during October-December 1984. The Team visited sites and conferred with Indian officials, institutional leaders and irrigation authorities at the Center and in Maharashtra, Madhya Pradesh, Rajasthan and Tamil Nadu, and at the Indian Institute of Management in Bangalore, and made extensive reviews of project documents and other relevant literature.

The Team gratefully acknowledges the assistance of GOI and State officials and many others in India including, in particular, Mahatma Phule Agricultural University, Ford Foundation and World Bank (India), USAID/India, and AID/W Asia Bureau and Science and Technology staffs. Regrettably, all of those deserving acknowledgment are too numerous to mention personally here. The Team is particularly grateful for the support and advice of Mr. Owen Cylke, Director, and Mr. William H. Janssen, Associate Director for Agriculture, USAID/India and their staff members; and to Dr. Mark Svendsen and Dr. Douglas Merrey, AID/W ASIA and S&T, respectively, and to Dr. Michael Walter, USAID/India, who reviewed and commented on the draft manuscript.

APPENDICES
VOLUME II

Each Appendix section was developed by an individual author as a background piece for the Irrigation Sector Strategy Review, USAID/India report. Each represents the efforts and opinions of its author, not necessarily the general opinion of the Team, and is in the form in which it was received (without specific editing).

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by Jagannathrao R. Pawar

BACKGROUND DATA

A set of background data entitled "A Statistical Profile of Agriculture, Nutrition and Development Trends in India: A Case Study of Maharashtra State" was developed for the report. This set of data is available for $25.00 from the Water Management Synthesis II Project, Agricultural and Irrigation Engineering Department, UMC 4105, Utah State University, Logan, Utah, U.S.A., 84322-4105.

Part I: Summary Profiles at the State Level

Part II: Detailed Statistical Profiles at the District Level

Part III: Selected Statistics on the Food System of Maharashtra from Studies Collected with the Assistance of J.R. Pawar and R. Balasanduram

Appendix D

IRRIGATION POLICY IN INDIA
Historical Trends & Public Policy Issues with Emphasis on the Deccan Plain States

APPENDIX D
Irrigation Sector Evaluation and Strategy Review
USAID/India

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A. SURFACE AND GROUNDWATER POLICY: AN OVERVIEW

The purpose of this document is to sketch the evolution of irrigation policy in India, to examine recent trends, and to explore public policy issues relating to future irrigation development. Indian irrigation is composed of two components: (1) surface irrigation includes canal and tank irrigation, and (2) groundwater irrigation includes tubewells and dugwells. Public policy in India has been largely focused on surface irrigation, while groundwater has been developed almost exclusively by the private sector.

1. An Overview of the Role of Surface and Groundwater Irrigation in Agricultural Production in India 1950-1970.

Irrigation has been the centerpost of India's agricultural development strategy during the planning period which began in the early fifties. Both surface irrigation constructed with public funds, and groundwater irrigation developed by the private sector have made major contributions to agricultural growth in the twenty years following Independence. Ashoka Mody provides a concise statement of that contribution, and a useful perspective of the roles of surface and groundwater in agricultural production.

> "To understand ... the reasons for growth in the fifties, it is necessary to go beyond the proximate sources of growth. It is well known that water is critical for agricultural production. ... In the fifties, increase in area under irrigation provided the main impetus for growth.

More than three quarters of the increase in area under irrigation was accounted for by government canals and tanks. Canals and tanks provide, in general, extensive irrigation, ie, irrigation of the type that implies "light irrigated crops" and "wide distribution of water". As a consequence, agricultural growth during the fifties was of an extensive nature."

"In the 1960's ... irrigation in general supported the more intensive application of modern inputs. It may be noted, in this connection, that the use of fertilisers and HYV seeds required controlled and intensive irrigation, ie, a given volume of water concentrated in a relatively narrow area. These requirements induced the growth of tubewell irrigation in the sixties. During that decade, about three quarters of the increase in area under irrigation was due to an increase in the area under tubewell irrigation. Extensive irrigation does not permit large cropping pattern changes, whereas intensive irrigation does. We therefore, do find that the extent of cropping pattern changes in the sixties was much more than in the fifties."[1]

Mody makes reference to several important facts and concepts which provide a useful starting point for the discussion which follows. Mody suggest that:

"Canals and tanks provide, in general, extensive irrigation, ie, irrigation of the type that implies light irrigated crops and wide distribution of water".

The term "extensive irrigation" is best characterized as a wide distribution of a small quantity of water over the largest possible area.

In contrast to extensive surface systems, wells tend to utilize water "intensively", that is by concentrating large quantities of water on smaller areas. The "light irrigated crops" which Mody refers to are largely food-grain crops which

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[1] See, Ashoka Mody, **Growth, Distribution and the Evolution of Agricultural Markets,** Economic and Political Weekly, January 2-9 1982 p. 24-38

are traditionally grown without irrigation[2]. The security of the yields in these foodgrain crops may be increased by applications of rather small or light doses of irrigation, which has led to them being called "light irrigated crops". In contrast such crops as potatoes and sugar cane are not cultivable without irrigation and require relatively regular and sizeable irrigation doses. Mody makes this point as follows:

> "Extensive irrigation does not permit large cropping pattern changes, whereas intensive irrigation does."[3]

Mody suggests that in the fifties agricultural growth came from an increase in the gross irrigated area in foodgrains which was made possible by the construction of "extensive" canal and tank irrigation schemes. Since the sixties, both yield increases and crop mix changes accelerated growth and were made possible by an increase in groundwater irrigation. It is interesting to note that Mody assigns three-fourths of the impact in the fifties to canal schemes and one fourth to groundwater, while in the sixties, he assigns three-fourths to groundwater and one-fourth to canal schemes.

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[2]Foodgrains in the Deccan region consist predominantly of sorghum, millets, pulses, rice and wheat. The proportion of the area cultivated in these crops which was irrigated in 1981 was 9%. Wheat is the only foodgrain crop in which more than 20% of the area was irrigated. In Maharashtra in 1981 40.6% of wheat was irrigated.- (See, S. Daines, A Statistical Profile of Agriculture, Nutrition, & Development Trends in India: A Case Study of Maharasthra State, prepared by SRD Research Group Inc. under subcontract to USU, Logan, Utah 1984 at page 9.) According to Byerlee and Polanco 73% of wheat is grown under irrigation in South Asia, as constrasted to 9% in Latin America. Very little of the wheat grown in the major wheat exporting countries of the world is irrigated. Byerlee notes that: "over half of the wheat produced in developing countries comes from irrigated areas. By contrast, irrigated wheat production in developed countries is negligible." (See D. Byerlee et al., **Wheat in the World Food Economy,** Food Policy, February 1983, p. 67.) The development of costly surface irrigation for the purpose of irrigating relatively low value grains crops is common only in Asia.

[3]/ Mody, op. cit. p. 27

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2. Role of Surface and Groundwater 1970-1985

Official estimates in the VIth Plan indicate that 34.6 million hectares of surface irrigation "potential" had been created by 1980 and 22 million hectares were being irrigated by groundwater.[4]

It is well known in India that surface irrigation projects actually irrigate only a part of the "potential" area which the projects were designed to irrigate. The difference between the area which surface irrigation projects were designed to irrigate, and the area they have historically irrigated in average rainfall years is referred to as "under-utilisation".

Estimates of "under-utilization" vary widely and the available data on this issue are examined in detail in the section C (2) in this paper. From that review it appears that only about half of the 34.6 million hectares of surface "potential" irrigation area is actually irrigated in an average year. This would indicate that as of 1980 about 17.3 million hectares were irrigated from surface sources and 22 million hectares from groundwater sources. This implies that groundwater accounted for roughly 56% and surface 44% of irrigated area.

As Mody suggests in the quote on page 4, there is general agreement that groundwater irrigation supports a higher value mix of crops than surface irrigation.- Few studies, however, have actually quantified the magnitude of the difference between the value of crops irrigated from wells with the value of crops irrigated from canals and tanks.

V.M. Rao and M.G. Chandrakant used estimates from a University of Agricultural Sciences study to derive an index of gross value of output per unit of land under tank, canal and well irrigation. Their rough index indicates that the gross value of production on well irrigation is about 1.8 times that of of canal and tank irriga-

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[4]Government of India, Sixth Five Year Plan 1980-1985, Planning Commission, New Delhi, at page 148.

tion.[5] Rao's index can be used to obtain a weighted estimate of the share of irrigated production value of surface and groundwater irrigation. My estimate, based on Rao's index, is that in 1980 about 70% of irrigated production value came from lands irrigated from groundwater sources, and about 30% from land irrigated from surface sources.

The groundwater share of production appears to be increasing over time. By 1985 it may well have reached or exceeded 80% of the value of irrigated production in India.

3. Future Potential of Untapped Surface and Groundwater Sources

The VIth Plan estimates that the ultimate irrigation potential is 73.5 million hectares from surface sources and 40 million hectares from groundwater sources.[6] If the surface "potential" is deflated by a realistic "utilisation" rate of 50% there would be a total of about 37 million hectares of possible surface irrigation and about 40 million hectares of possible groundwater irrigation. Using a 50% deflator for actual vs. potential surface irrigation and assuming VIth plan figures, there would be an untapped potential of about 18 million hectares of groundwater and 20 million hectares of surface irrigation.

Chambers, writing in 1984, provides a very important updating of the estimates given in the VIth Plan based on more recent information.

> "Estimates of the useable renewable recharge of groundwater have been rising, and have more than doubled in the past 14 years. ... the groundwater estimates of the CWGB (Central Groundwater Board) give a utilisation of 10.0 m.ha.m. against a potential of 42.3 m.ha.m., or a utilisation of only 24 per cent of the potential. As these figures are reconciled, the estimate of gross hectares irrigable can be expected to rise. One

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[5] See V.M. Rao & M.G. Chandrakant, "**Resources at the Margin: Tank Irrigation Program in Karnataka**", Economic and Political Weekly, June 30, 1984 p. A56.

[6] See, VIth Plan opcit, at page 148.

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unreferenced source gives this as 72 million hectares, of which only a quarter (18 million hectares) is said to be utilised. Whatever the final figures, there seems no room for doubt that the goundwater potential of India is much greater than earlier believed, and that it presents immense opportunities for millions of the rural poor. The spread of rural electrification and the increase in lift irrigation have been little short of spectacular during the past three decades. In one perspective this can be seen as a countryside scramble for a big frontier."[7]

4. Comparison of the Costs of Developing Surface and Groundwater Irrigation.

National Plan estimates for the public cost of developing a hectare of "potential" for surface irrigation during the period 1980-84 is Rs. 14,820, or approximately, US$ 1,500. For groundwater, the National Plan estimate is Rs. 4,500 or approximately US$ 500/ hectare irrigated.[8]

One hectare of "potential" irrigation is not the same as one "actual" irrigated hectare, as discussed above. Cost estimates based on the VIth plan must therefore be adjusted by the difference between "potential" and "actual" to arrive at a cost estimate which can be compared with groundwater. Using a 50% utilization estimate of surface irrigation, the average cost of a surface hectare of actual irrigated area rises to approximately US$ 3,000 as compared with a cost of US$ 500/ha. for groundwater.

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[7] See Robert Chambers, To the Hands of the Poor: Water, Trees and Land, Paper for the Institute of Economic Growth, Silver Jubilee National Seminar Programme, Delhi April 27-30, 1984 pp. 23, at p. 10-11.

[8]/ Government of India, Sixth Five Year Plan, Planning Commission, New Delhi, at pages 152-163. The estimates of costs per hectare are computed in the following way. The plan proposes to spend 8,448 Crore Rs. on surface irrigation, and with that investment to create 5.7 million hectares of surface irrigation potential. That results in a cost per hectare of Rs. 14,820/Ha.. The Plan proposes to develop 8 million hectares of minor irrigation at a cost of 1,810 Crore Rs.in direct investment and 1,700 Crore Rs. of "institutional investment". Of this 8 million hectares, almost all (7 million) is groundwater. If we assume groundwater development costs to be a proportionate share of the total, the public cost of development would be Rs 2,250 per hectare irrigated for direct investment and about double that -- Rs. 4,500 per hectare -- if the institutional costs are added in.

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The India-wide cost estimates presented in the last paragraph may be compared with those derived by the author using macro and micro data for Maharashtra. This comparison indicates that groundwater is more than twice as expensive to develop in the Deccan where hard rock substrata and a scarcity of significant aquifers increases the costs and decreases the capacity of wells. As a result, surface irrigation in the Deccan appears to cost approximately $3,700 per hectare actually irrigated, compared to $3,000 for India as a whole. The increased cost in the Deccan may be due to a scarcity of perennial rivers and more costly storage sites.[9]

In making the comparison between surface and groundwater costs I have not included operation and maintainance (O&M) costs in either case. It is likely that the costs of O&M on groundwater, including energy, are substantially higher for groundwater, although O&M is by no means insignificant on surface systems. The added cost of O&M on wells is unlikely to balance off more than a small part of the cost advantage of groundwater over surface irrigation. Giving what appears to be a liberal allowance for energy costs in groundwater, the cost of groundwater development would probably be about one third that of surface water on a per hectare basis, and about one fourth on a per unit of production basis.

6. Policy Issues Related to Groundwater.

As outlined above, groundwater has a significantly lower development cost, and supports a higher value of production per hectare when compared to surface

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9/ See S. Daines Institutional Overview of Minor Irrigation in the State of Maharashtra India, SRD Research Group Inc. Logan Utah, November 1983 pp. 45. (Prepared under subcontract to WMSII Project of USAID). In that document it was estimated that surface irrigation in Maharshtra costs approximately US$2,800/ hectare for major and medium projects, US$ 7,000/ hectare for public sector minor projects, and US$ 2,000/ha. for local sector minor projects. These figures are for "actual" area historically irrigated rather than for "potential" created. A weighted average of these surface irrigation development costs for Maharashtra based on area irrigated is US$ 3,700/ha. The estimate for Maharashtra for groundwater development costs is US$1,200/Ha..

irrigation. Past Secretary of Irrigation in India, B.B. Vohra has been vocal as an advocate of a major shift in public policy and public expenditure in the direction of groundwater[10]. Why should the government, he and others argue, continue to invest heavily in surface systems which are much more difficult to manage, when immense groundwater reserves lie, in many areas, just a few meters under the farms?- This issue is one of those discussed by Pant in his article Issues in Irrigation Development:

> "In case the new estimates (of groundwater potential) are to be relied upon then there are valid reasons for the argument that there is an excesssive pre-occupation with large scale irrigation projects and pre--emption of large financial resources for them leading to an almost criminal neglect of ground water development."[11]

Approximately twelve billion dollars are allocated in the VIth Plan to irrigation in order to develop about fourteen million hectares of irrigation potential. At current utilization rates, only about 11.5 million actually irrigated hectares would result, with an average cost of roughly one thousand dollars per hectare. Of that 11.5 million hectares, 7 million would be groundwater or about sixty percent. Using Rao's index of value of production to adjust the estimate in terms of value rather than area, 75% of the value of irrigated production resulting from Plan investments would come from groundwater development. The unfortunate result is likely to be that one fourth of the irrigation investment (the three billion spent on groundwater) will generate three fourths of the benefits.

It should be noted that if all twelve billion dollars of the public irrigation investment were to have been invested in groundwater development, the actual irrigated area would have been 26 million hectares during the Plan period instead of

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10/ B. B. Vorha, Land and Water Mangement Problems in India, Second Edition, Training Division, Department of Personnel and Administrative Reforms, Ministry of Home Affairs, New Delhi, January 1982, pp. 124.

11/ Niranjan Pant, **Issues in Irrigation Development,** Economic and Political Weekly, Delhi, July 23, 1983 at page 1315.

the 11.5 million planned. India can hardly afford to lose 15 million hectares of stable and relatively efficient irrigation. Rogers concludes a recent paper on irrigation in India with thoughts directed at the groundwater issue.

> "Given the rates of return and the remaining potential for irrigation by various technologies the possibility arises that, maybe, the planning goals should be changed from the existing concentration on surface to the groundwater developments, and an improvement of the existing surface water systems. Planning for efficient use of the existing ... surface irrigation systems and expanding the groundwater to its full potential ... looks like an attractive strategy. ... This approach could significantly reduce the public expenditures on irrigation, perhaps by as much as 50%. The decision to change the strategy should not be taken lightly, however."[12]

Market demand for food and fiber in India is causing a slow but steady transition from a subsistence agriculture to a more diverse and commercial rural economy with a larger role for fruits, vegetables and milk products. More reliable irrigation based on private groundwater development appears to be supporting if not leading this transition. The groundwater development issue is probably the single most important issue for irrigation policy in India for the balance of this century.

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[12]Peter Rogers, Irrigation and Economic Development: Some Lessons from India, Division of Applied Sciences, Harvard University, Cambridge, 1983, at page 148.

B. HISTORICAL TRENDS IN SURFACE IRRIGATION POLICY

1. Trends and Objectives in Public Policy for Surface Irrigation

a. Public Policy Phases 1875-1985

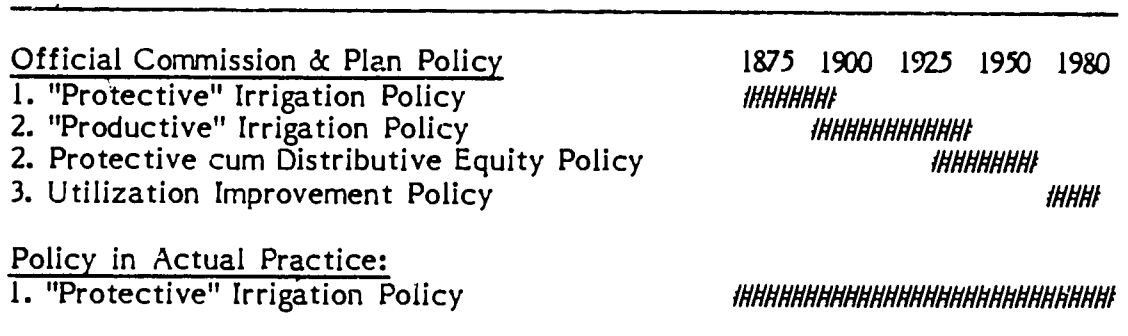
Official surface irrigation policy has evolved in identifiable phases over the past century. The official irrigation policy which may be found in commission reports and planning documents has developed differently than the policy which has been used in the field[13]. Actual "field" policy may be found in design manuals, regulations, and field administration procedures. Official policy may be segmented into four main phases:

13/ Irrigation commission reports reviewed include the commissions of 1901, 1928, 1938, 1961, 1971, and 1981.

1870-1900	The Famine Commissions & Protective Irrigation
1900-1950	The Irrigation Commissions & Productive Irrigation
1950-1980	The Planning & Irrigation Commissions: Blending Equity & Productivity
1980+	The Utilization Commissions: Official Policy meets Actual Practice

Policy in actual practice has been essentially unchanged since the Famine Commissions of the 1870's. The policy actually practiced in the field has remained in a single "protective" irrigation track, while irrigation and planning commissions have attempted to make major policy shifts. These various policy stages are diagrammed in Figure 1:

Figure 1
Policy Phases in Surface Irrigation 1875-1985



The official irrigation commissions during this period seem to have recognized changed circumstances and saw the need to make changes in light of experience and updated analysis. The policy actually practiced in the field, however, continued in basically the same "protective" mode and became more entrenched with the passage of time.

b. Public Objectives in Irrigation Policy

It is clear from the historical evolution of public irrigation development in India that irrigation was viewed as a way of reducing the risk of famine caused by droughts. Irrigation was developed by the government as a way of stabilizing foodgrain production in unusually dry years. These origins have left a deep imprint

on irrigation policy and have shaped the physical configuration of irrigation which is still being developed.

An alternative objective could have been to develop irrigation to increase production and support economic development in rural areas. Stated differently, one could invest in irrigation to stabilize output and reduce year to year variation, or one could develop irrigation to increase output and generate productive employment in rural areas. The two objectives, stabilization or maximization of output may appear, at first blush, to be complementary. In many respects they are, yet the analysis presented below concludes that in the India case an over-emphasis on the stabilization objective has, in fact, led to systems with substantially lessened productivity and equity impacts. Taking the "stabilization" path led to "extensive" systems, taking the alternative "productivity" path would have led to "intensive" systems with significanly higher output, employment and equity impacts.

Not only did the "stabilization" objective dominate irrigation policy during its formative years, stabilization is still the dominant policy theme. The first substantive paragraph in the irrigation section of the VIth Plan which establishes the policy rationale for public investment in irrigation reads as follows:

> "Irrigation contributes substantially to the agricultural price stability,- by removing to a large extent the elements of uncertainty in the agricultural production. Therefore, expansion in irrigation would be envisaged as a part of a price stabilization policy.[14]"

One is left with the impression that in the minds of the planning comission, irrigation policy is a subpolicy inside a general price stabilization policy. The stabilization objective as stated in the above quoted paragraph from the plan is consistent with a century of deeply entrenched public policy tradition in Indian irrigation.

14/ VIth Plan, op. cit. p. 149

2. The Famine Commissions & "Protective" Irrigation in the Nineteenth Century

During the last half of the nineteenth century, serious famines prompted the British authorities to convene commissions to elaborate what might be called "official" irrigation policy. The unique contribution of these "famine commissions" was their creation of a category of irrigation works which they termed "protective" as contrasted to "productive" systems.

The policy of public irrigation works to protect against famine did not originate in the nineteenth century, yet, the policy framework which was elaborated by the famine commissions was a significant step in the direction of institutionalizing and giving the famine protective irrigation policy a long-term lease on public attention and funding.

> "After the great famines of 1877-78 the concept of "protective" works was introduced. The protective works were essentially introduced as famine relief works. ...the projects that were taken up in the 20th century did not match the economic performance of some of the earlier canals. The government became primarily concerned with averting the risk of famine.[15]"

The famine protection orientation in surface irrigation policy led to design and administration practices which have lasted to the current day even though the official policy itself which gave rise to them has undergone periodic change. The two principal design and administration effects of the "protective" policy strategy of the late nineteenth century are, what I shall call, the "over-extended command" result and the "crop restrictions" results.

15/ Rogers, op.cit. p. 149

a. The Impact of Famine Protection Policy on Over-Extending Irrigation Commands-

Protective irrigation policy called for designs which extended canal systems substantially beyond the areas which could be provided in most seasons with reliable and substantial water supplies. Irrigation systems so designed and constructed to provide low reliability and low volumes of water to large areas are termed "extensive" systems. The way the extensive policy worked out in practice can be seen in the 1867 report of the Inspector General of Irrigation:

> "...the Government now having adopted the policy of extending irrigation generally, and so far as it is possible in a manner that shall to the utmost guard against the worst effects of severe drought ... The first limitation is of the supply of water (in) proportion (to) the cultivable area within the reach of each canal, ... This porportion might be fixed at one uniform rate for the whole canal, say one-third or one-fourth of the cultivable area..[16]."

The Inspector General is not estimating that systems are really designed to irrigate only one-third or one-fourth of the cultivatable area inside the reach of their canals, he is very transparently explaining the "protective" strategy. The strategy is to extend the canals to much more area than can be supplied with water in relatively dry years. The "protective" idea is to give the maximum number of farmers a little bit of water, realizing that it won't irrigate all of the cultivated land under the canals. The ratios mentioned by the Inspector General are purely hypothetical. Systems built in line with the protective policy have historically been able to irrigate about half of the irrigable command area (ICA) in average years. The Inspector General's hypothetical range (one-third to one-fourth) may come quite close to ratio of ICA which average "protective" systems have irrigated in dry years. The analysis below indicates that the average commands designed under the protective strategy had the capacity to irrigate almost half the area in the command, as contrasted to the inspector generals estimate of one

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16/ W.E. Gustafson & R. B. Reidinger, **Delivery of Canal Water in North India and Pakistan,** Economic and Political Weekly, as quoted in Rogers op. cit.

third or one fourth.

In the late 1800's India formalized and institutionalized the design and administration of an irrigation policy which has survived in practice, if not in commission reports, to current times.

b. Protective Irrigation Policy and Crop Restrictions.

The second major policy theme which emerged from the famine commissions was the involvement of irrigation policy in restricting the crops which could grown with surface irrigation water. It was obvious at the outset that to enforce an "extensive" policy, one would have to not only restrict the size of "doses" of water but also the kinds of crops which could be irrigated. The extensive policy inevitably carried irrigation policy into crop policy and the two have been intertwined ever since. These restrictions are often called "localisation requirements" or "proscribed cropping patterns". The degree and nature of crop restrictions vary widely between Deccan states. Restricting the crops which could be grown was one of the major differences between productive and protective works, as the 1962 Barve Commission explains:

> "An aspect, ... in which protective works differed from productive works, was the management of the works in relation to the distribution of water for growing crops.The difference made was by reference to the protective intent of the work. Because of this intent, the area under sugar and other high cash crops or perennials was restricted in the beginning of the year so that the demand for water for dry food crops may fully be met if the rainfall proved deficient later in any year. As a result of this bias in administration, the area under high cash crops, under normal rainfall, was much less that it otherwise would have been."[17]

The commission's point in the last sentence is important to an understanding of the development of irrigation policy. The way "protective" irrigation systems

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17/ Irrigation Commission Report, Government of Maharashtra, 1962 at page 61.

were administered ended up restricting and reducing the area in "high cash crops or perennials", not just in water scarce years, but in normal rainfall years as well. The protective policy therefore favored "dry food crops" (grains).

c. The Separation of "Protective" and "Productive" Irrigation Systems in the Nineteenth Century.

Another characteristic which distinguished nineteenth century irrigation policy from twentieth century policy was the open frankness and clarity of distinctions which were made between "protective" and "productive" systems. In the latter part of the nineteenth century "protective" and "productive" systems were designed, financed, and administered separately. They were called by names which accurately and openly described their radically different objectives. Policy makers, designers and administrators admitted to themselves and described openly in policy documents what they were doing and why. In this they were both sophisticated and naive at the same time. Their recognition of the realities and complexities of good benefit cost analysis is surprising. Their resistance to the temptation of manipulating rates of return to make "protective" projects appear "productive" should embarrass most Bureau of Reclamation, World Bank and AID benefit/cost practicioners. Rogers reviews Indian practice before the turn of the century:

> "Despite some ambiguity with regard to discounting, the discussions in ... Indian engineers' writing show a great concern with the economics of projects and the need to assess correctly the attibutable costs and benefits. The discussion has a very modern sound to it. ... About this time (1879) the British also introduced the concepts of "productive" (and) unproductive "protective" works. A "productive" work is one that the net revenue derived from the project within 10 years after the date of completion is more than a definite percentage of total capital outlay. This percentage was fixed by the central government from time to time... An unproductive' work was one that did not meet these criteria. After the great famine of 1877-78 the concept of "protective" works was introduced."[18]

18/ Rogers, op. cit. at page 5-6

In 1900 Wilson reviewed 35 productive works and 5 protective works. Until the early twentieth century protective and productive works were designed, operated and financed separately using different standards and procedures. By 1900 only 4% of the irrigation potential was in systems of the "protective" category, yet the protective policy contained politically vigorous characteristics which allowed it to quickly dominate the irrigation scene in the twentieth century.

3. The Early Twentieth Century: The Irrigation Commissions vs. Actual Practice.

a. The Irrigation Commissions and Official Policy.

An official Irrigation Commission was convened just shortly after the turn of the century to evaluate the last twenty five years of experience with "protective" irrigation. They reached the conclusion that not only was protective irrigation not "productive", but that it was not "protective" either. The comission's conclusion that protective irrigation fails to effectively protect is a conclusion of far reaching and vital importance to Indian irrigation policy -- indeed to Indian agricultural policy in general. The reasons for the failure of the "protective" policy to protect are clearly outlined in the 1903 commission report. Realizing that the protective strategy had led them down a blind alley, the commission sought to undo the error and abolish the policy. At the time (1901) it was a small problem; protective systems comprised less than 4% of surface irrigation. Yet comission attempts to stamp it out were to prove ineffective not just in 1903 but in repeated attempts during the next half century. The "protective" policy had already developed an unusual vigor and resistance to logic and to official comissions.

It is important to realize that there were originally two types of "protective" works financed out of the Famine Insurance Fund, irrigation and railroads. Famines in India have almost always been localized in certain areas and have seldom affected the country as a whole. The largest difficulty encountered in a famine was therefore the transport of surpluses to an affected region. Railroads and protective irrigation were therefore viewed as alternative ways of dealing with famine in

the nineteenth century. By the time the 1901 commission was formed it was no longer difficult to transport cereals in most areas. The 1962 Irrigation Commission reports this history as follows:

> "The (1901) Irrigation commission was disposed to doubt whether this (protective) system ... had any real advantage even from a protective point of view. The Commission noted: "The mere extension of the area under food crops in a year of famine is ... no longer a matter of the first importance as it was in 1877-78. There is no longer any difficulty in getting foodgrains into the provinces in the year of drought. What is really wanted is remunerative agricultural employment for the people; and as long as this can be found for them by means of irrigation works, it is a matter of little importance whether they are employed in the cultivation of food crops or of such a crop as cotton or sugarcane. The Irrigation Commission (1901) also suggested the abolition of the distinction regarding source of finance as between productive and protective works."[19]

The commission's simple and logical finding, that remunerative employment is the key to protecting the poor has stood the test of three-quarters of the century of experience and quantitative analysis. However, 1901 comission's recommendations to abolish the policy was unheeded. At the time of their report 96% of irrigation was in the "productive" category and only 4% was in the "protective" category. The effect of the comission's removal of the clear procedural wall between the policies appears to have had just the opposite effect which the comission intended. With the wall down, the inherently vigorous 4% (protective) policy rapidly displaced the 96% productive policy and dominated irrigation policy for the next eighty-five years.

The progression of this process from the 1901 commission to 1938 is traced as follows:

> "When in 1928, the States were empowered to raise loans with the consent of the Government of India, for the execution of irrigation works, the distinction between productive and protective works ... came to an end. However, the policy of administration continued to be coloured... by protective intent. It was in this context that the Bombay Irrigation Enquiry

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19/ Irrigation Commission Report, Government of Maharashtra, Nagpur 1962, at page 61.

Committee of 1938 recorded the view that the best protection a canal can give is afforded when the supply is used from year to year, to obtain crops of the maximum value and advocated a redistribution of canal facilites to secure this important advantage."

Thus on the eve of World War II, irrigation commissions were still reaching the same conclusion that they had reached in 1901 about the "protective" irrigation policy, that it was "protective" of anything, least of all the welfare of the poor.

The commission stated that the actual practiced "policy of administration continued to be coloured" by the "protective" policy even after the commission recommendations. The over-extended design criteria and crop restrictive administrative proceedures appear to have continued. Within a few years after the 1938 commission the protective policy was to get a permanent lease on life and funding by the cataclysmic events of the forties—Independence and the Bengal Famine.

b. Possible Explanations for the Perpetuation of the Protective Policy.

There is little doubt that while the Commissions were pulling in the direction of a productive policy which would end crop restrictive practices and over-extension of canal systems, the policy in actual practice had made a move in the other direction and had become solidly entrenched there. The question is what were the forces which had entrenched the protective policy. I begin with the assumption that the protective policy was supported by groups with sufficient power to sustain it, and that such group(s) perceived it to be in their interest. Five groups are considered as possible candidates:

1. The irrigation technical bureaucracy (engineers)
2. The local political bureaucracy (tax collectors)
3. The Irrigation Commissions
4. The rural poor and small farmers
5. Large farmers

It appears probable that the emerging irrigation technical group and local political bureaucracy predominated in the determination of actually practiced irrigation policy during the first half of the twentieth century. I eliminate the rural

poor and small farmer groups as possibile policy determiners for the reason that they were relatively powerless in the pre-independence period. I eliminate the large farmer group because they would naturally benefit from a policy which favored cash crop irrigation and the concentration of irrigation on their properties. They are not likely to have been supporters of the "protective" policy because it was not in their narrowly defined interest.

The official irrigation commissions may be eliminated by the terms of their reports and recommendations. The comissions saw the weakeness of "protective" logic and its failure in historical experience and recommended its abolishment.

The process of elimination suggests that the emerging technical irrigation bureaucracy and the local political bureacracy were the groups who perpetuated the protective policy during the first half of the twentieth century. It is important to realize that what I have called local political bureaucracies in the colonial period were not really political bureaucracies but, rather tax collecting bureaucracies.

There are two obvious motives which probably explain the support of the engineers and the tax collectors of the protective policy. The first motive relates to the potential of the protective policy for extending the power base of the tax collectors and engineers. The second obvious motive is a narrower pecuniary one.

The protective policy gave local engineers and tax collectors much more flexibility. Under the "protective" policy umbrella engineers didn't have to be bothered by economists and accountants evaluating their designs and controlling the approval or rejection of their projects.

> "Protective works were essentially introduced as famine relief works. Since they were not evaluated according to economic criteria many observers believed that the existence of these projects has led Indian irrigation engineers, economists and planners to be very casual in the evaluation of all irrigation projects. Certainly the projects that were taken up in the 20th century did not match the economic performance of some of the earlier canals."[20]

20/ Rogers, op. cit. at page 6.

The protective policy took the focus off of economic analysis and placed it in the engineers domain; and irrigation in India has remained essentially immune to economic scrutinty ever since. Placing irrigation beyond serious economic evaluation also made irrigation projects into very flexible local political tools. One can find many areas in India where there are probably no economically feasible surface irrigation sites. Yet there are no populated areas where a "protective" system is not feasible. Irrigation has been for many decades the most visible and sizable public expenditure in rural areas. It is understandable that the two public bureaucracies in rural areas who lived from that expediture would favor a policy which gave them the most flexibility and control over it.

The second motive suggested above is a pecuniary one; the engineers and tax collectors stood to gain monetarily from the protective policy. With a few sentences and two references to the literature, I avoid the rather distasteful task of examining the evidence and details of how engineers and local politicians obtain "informal" money from irrigation. Irrigation is the largest public expenditure in rural India. Engineers and local politicians have been successful in getting a major "informal" slice of both the costs and benefits of irrigation. "Informal" money from irrigation in many different forms accounts for an important part of the incomes of many local politicians and irrigation engineers in irrigated areas. B. D. Dhawan in his review of The Role of Irrigation in the Development of India's Agriculture gives his opinion on irrigation expenditure:

> "... it is common knowledge that corrupt practices and bribes account for a substantial portion of the construction as well as the maintenance cost of public works."[21]

Readers interested in an analysis and examination of evidence on "informal" income mechanisms through which engineers and local politicians "participate"

21/ B. D. Dhawan, **Partial View of Irrigation Problems**, Economic & Political Weekly, December 1977 p. 2009, and **A Review of the Role of Irrigation in the Development of India's Agriculture,** Indian Society of Agricultural Economics, Bombay 1976 pp. 201.

in the benefits of irrigation are referred to Wade's able and tasteful treatment of this subject.[22] I leave the burden of explaining "how" engineers and local politicians obtain "informal" money from irrigation to Wade, Dhawan and others, and proceed to the more interesting and relevant question of why "protective" irrigation policy would be preferred by the local recipients of "informal" incomes.

On one hand it seems logical that an economically productive system would create more total wealth and that engineers and local politicians would have a larger pie to get their "informal" slice from. There are, however, detailed elements in the "protective" policy which cut strongly the other way and provide the engineers and local politicians more leverage to get an "informal" slice -- even through the pie may be smaller it can be tapped more easily.

We should first recall that two basic elements constitute the core of the "protective" policy; first, an over-extended canal system requiring and permitting selective distribution of insufficient water supplies, and, secondly, control over the cropping pattern through crop restrictions.

c. Monopolistic Behavior and the Balance of Supply & Demand Forces in Protective Systems

In a concentrated smaller canal system where the demand is designed to be no larger than the supply, there are fewer alternatives for engineers and local politicians to withold water from some farmers and give it to others. The further the canals are extended beyond the reach of the water in the reservoir, the larger the number of farmers who are inside the reach of manipulation of water for "informal" purposes. The margin by which demand for water exceeds the supply defines the margin of power by which those who control the supply can "tap" the incomes which flow from that supply. It is clear that the ratio of demand to supply is

22/ Robert Wade, **The System of Administrative and Political Corruption: Canal Irrigation in South India,** Journal of Development Studies, April, 1982 (V18 No.3) p. 287

much higher in protective systems, as the core intent of protective policy was to bring the largest possible number of farmers inside the reach of a very small quantity of water. Expanding demand by extending the canals without increasing the supply to meet it, correspondingly increased the power of those who controlled the supply to "informally" tap the benefits. It should not be surprising that the recipeients of this monopolistic power should perpetuate the policy that conferred it.

The behavior of the engineers and local politicians in perpetuating the protective policy appears completely rational when viewed from the point of view of a monopolist supplier. In most monopolistic situations the demand is fixed by the size of the market and the monopolist seeks to create a supply/demand imbalance by reducing the supply. The monopolist then "harvests" the imbalance he has created through pricing mechanisms in an open market. In the Indian irrigation situation the supply is the fixed side, and the monopolist's strategy is to expand the demand in order to create the imbalance needed to generate monopolist power. The mechanism for expanding demand is to extend the "market" by building extra canals to bring more farmers within the reach of the limited water. The extended canal creates additional demand without additional supply and monopoly power is created. The ones who control the supply (engineers and local politicians) can then "harvest" the imbalance they have created through a multitude of "informal" mechanisms, some of which are described by Wade in the article referenced above.

d. Crop Restrictions as an Expansion of Monopolist Control.

As important as the balance of supply and demand forces in an over-extended canal system is the unique control position which the "protective" policy gives local engineers and politicians over the choice of crops the farmer can grow. Even in systems where supply may nearly equal demand, protective policy gives irrigation officials and local politicians some control over the crops which can be grown with the water. This insertion of crop restrictions into irrigation policy

gave to engineers and local politicians immense leverage and opened up additional possibilties for "informally" tapping rural surpluses. Wade comments on these possibilities as follows:

> "The prescription of penalties for misuse of water, ... where there are ... arrangements which specify permitted cropping patterns ... creates a valuable asset for irrigation officials: for farmers can then be induced to pay the officials some proportion of what they would have to pay if their cases were to be reported."[23]

The irrigation commissions of the early twentieth century may not have understood in detail the micro-economic and political mechanisms at work in so called "protective" systems, but they did see clearly that the one group these systems did not "protect" was the poor.

4. Independence and the Era of Planning: 1950-1980

It would appear from the discussion above, that obvious economic and political forces perpetuated the protective policy during the first half of the twentieth century. During the forties, two major events were to further entrench the hold of the protective policy on surface irrigation development and perpetuate it into the eighties and beyond. These two events were the Bengal famine of 1943 and Independence in 1947.

a. The Bengal Famine and the Post Independence Drive for Self-Sufficiency in Food Grains.

Just four years before Independence India and the world were shocked by the death of some 3 million people in what came to be termed The Bengal Famine of 1943. Sir Theodore Gregory and his Foodgrains Policy Committee identified the cause as a shortfall in food grains availability. His committee proposed a "grow more

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23/ Robert Wade, **Performance of Irrigation Projects**, Economic and P(dlitical Weekly, January 17, 1976(d

food (grains) campaign" along with a public procurement and distribution system for grains[24].

Both Gregory's diagnosis of the causes of the tragedy, and his proposed solutions were disputed pre-emptively by Mahatma Gandhi in 1942. From newspaper interviews with Gandhi in December 1942 it appears that he felt that the British would look for some simple acute cause and prescribe some correspondingly superficial solution. According to Gandhi (who cited contemporary nutritionists for his evidence) the deaths were caused more by the chronic deteriorated economic position of the masses than some temporary supply shortfall. This poor economic position, in Gandhi's view, had resulted in accumulated chronic malnutrition over a period of decades, and the shortfall, if there was really any, had triggered rather than caused the problem. Gandhi outlined his position as follows:

> "I would like to draw attention to the ... root causes of the ... distress now prevailing. ... any action in the direction of a long term policy to remedy present crisis must take cognisance of this deterioration in the economic condition of the masses, as allowed to progress and accentuate itself during the last few decades. Any superficial measures can, at best, bring only temporary relief -- if at all effective. A tremendous wholehearted and well laid-out plan is called for and cannot be avoided, eventually, and should be delayed no longer."[25]

It is clear that Gandhi saw the deaths in Bengal as the result of rather complicated and chronic conditions, rather than a simple acute shortfall in food-grain availability. Quoting medical experts, Gandhi stated:

> "At least 80 million people of India (are) perpetually hungry. ... disease (is) increasing steadily and rather rapidly. In Bengal 78 per cent of the population (are) undernourished. The cumulative effect of the above-men-

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24/ Foodgrains Policy Committee, **Conclusions & Recommendations of Foodgrains Policy Committee**, reproduced as Appendix III to K. Santhanam, The Cry of Distress: A First Hand Description and an Objective Study of the Indian Famine of 1943, Hindustan Times, New Delhi 1943, 185 p.

25/ (see Mahatma Gandhi, Harijan, January 25, 1942 as reproduced in K. Santhanam, A First Hand Description and an Objective Study of the Indian Famine of 1943., Published by the Hindustani Times, New Delhi, December 1943 pp. 183 at page 128-129)

tioned factors in operation presumably for decades and more, has now made itself felt to a horrifying extent."[26].

These physical problems seem to have been caused in Gandhi's view, not by temporary shortfalls in foodgrain production, but rather by "root causes" related to employment and a "deterioration in the economic condition of the masses."

"There may be grain available but no money to buy it with. There is no money because there is no employment. This has to be found. Every available source has to be tapped so that there is no want of employment."[27]

Ghandhi's concise diagnosis of the root causes has not only been vindicated by Amartya Sen's important recent re-examination of the Bengal Famine, it also fits with broader recent analyses of world hunger. Thomas Poleman in his 1981 Reappraisal of the Extent of World Hunger after criticizing the findings of the Presidential Commission on World Hunger says:

"But, if the Commission took the path of idealism and political naivety, it does not follow that it failed to pinpoint the causes of hunger. It did so with admirable clarity: "... they are hungry because they are poor, and they are poor because they do not have jobs that provide a decent income." This statement may sound trite, but it is not. To have said it 20 years ago was to risk derision. When I said it in 1975 in an article in **Science**, a number of people wrote to say that for them it was an utterly new idea. This is because it flies in the face of the notion -- erroneous but still widely held -- that there is not enough food to go around, and that mankind is simply losing the race between food production and population growth first visualized nearly 200 years ago by Robert Malthus.

"That there is a race, no one questions. But it is not the mindless one

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26/ see Gandhi, op. cit. p. 129

27/ See, Gandhi, op.cit. p. 7. Gandhi's assessment that there was foodgrain available during the famine has been vindicated recently in the important work by Amartya Sen, Poverty & Famines: An Essay on Entitlement and Deprivation, Oxford Univeristy Press, Delhi, 1981. Sen proves, to this author's satisfaction that there was essentially no short fall in food grain availability in Bengal during the years preceding the famine. Sen explains the deaths based on the lack of buying power in the hands of certain classes of people, principally rural landless laborers.

forseen by Malthus in which food and population push relentlessly toward some saturation point and ultimate mass starvation. Rather it is a race ... in which more and better jobs and the elimination of poverty act as the equilibrating mechanism."[28]

There appear to be two very different diagnoses of the causes and solutions to famine. The first I call the "foodgrain shortage" view, and the second I call the "employment shortage" view. These views have much to do with irrigation policy because each view suggests a different kind of irrigation strategy.

The foodgrain shortage view is that famines and hunger in general are caused by cyclical and structural shortfalls in foodgrain availablity. The solution to the foodgrain shortage problem appears straightforward; protect foodgrain production in drought years through irrigation, store foodgrains from surplus years and control prices so that the poor can afford it.

The employment shortage view is that famines and hunger in general are caused by the lack of economic purchasing power in the hands of the poor, and that poverty is, in turn, caused by a lack of remunerative employment. The solution from this point of view is to create productive employment.

One hectare of foodgrains creates an average of about 30-60 person days of employment under current Indian technology. One hectare of the other crops taken as a group creates an average of 200-300 person days of employment[29]. Foodgrain cultivation creates less than one fifth the employment per hectare that other "high cash" crops do. Gandhi's reccomendation with reference to irrigation is interesting in light of these employment figures and his identification of a lack of employment at the root cause of famine and hunger. On the eve of the Bengal Famine he wrote:

28/ See, Thomas T. Poleman, **A Reappraisal of the Extent of World Hunger**, Food Policy, November 1981, p. 236. The report of the Presidential Commission cited by Poleman is: Presidential Commission on World Hunger, Overcoming World Hunger: The Challenge Ahead, Washington D.C. 1980, p. 49.

29/ for estimates and data sources on crop employment coefficients see S. Daines, Selected Productivity, Equity and Economic Issues for Irrigation in India, Appendix E, to the USAID India Irrigation Sector Evaluation and Strategy Review. SRD Research Group, Logan, Utah, produced under sub-contract to USU.

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"By far the most important part of the work consists in educating the villagers to keep what they have and to induce cultivation of fresh crops wherever water is available. This requires widespread and intelligent propaganda. It is not generally known that bananas, potatoes, beet root, yam and suran, and in a measure pumpkin are food crops easily grown."[30]

The Foodgrains Commission convened in the wake of the Bengal Famine understandably took the "foodgrain" shortage view of the famine. Their proposed solution was widely accepted by the Indian government after Independence and India embarked on an agricultural strategy dominated by a single objective: to become self sufficient in food grains. This general agricultural strategy had important implications for irrigation policy, and more specifically for the choice between "protective" vs. "productive" irrigation policy.

The central focus on agricultural policy after Independence on foodgrain production provided additional and compelling support for the "protective" policy and all of its elements including over-extended canal systems and restrictions on non-grains crops. An erroneous interpretation of the Bengal famine led to a further entrenchement of an erroneous irrigation policy. The Bengal famine resulted in the same "protective" irrigation logic that the famines in the last century had led to. In 1985 we stand about the same distance in time from Bengal Famine as the early irrigation commissions were from the nineteenth century famines. There is a sense of history repeating itself. We could use the very words from the commission reports to assess the experience with protective irrigation in the last thirty five years:

"The (1901) irrigation commission was disposed to doubt whether this (protective) system ... had any real advantage even from a protective point of view. What is really wanted is remunerative employment for the people; and as long as this can be found for them by means of irrigation works, it is a matter of little importance whether they are employed in the cultivation of food crops or of such a crop as cotton or sugarcane. ...the best protection a canal can give is afforded when the supply is used from year to year, to obtain crops of the maximum value (we) advocate a redistri-

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30/ see Gandhi, op. cit. p. 7

bution of canal facilities to secure this important advantage.[31]

Without even confronting the logic and evidence presented by its own irrigation commissions or its founding father, independent India embarked on a program to construct the largest irrigation system in the world in the "protective" mode.

b. The Rise of A Local Political Power Structure & Rural Voting Constituencies.

Democracy came to rural India rapidly after Independence. The population of India included more poor, rural and illiterate voters than any democracy in history.- Local power structures had to deal with the voting rural masses. In the readjustment of local power structures after independence many of the same persons who were running the villages before independence weathered the change without any real loss of power. But in post-independence India there was a new approach to local power which had to reckon with the rural vote.

Water for votes is a powerful local political tool in any democracy. It is easy to see that protective irrigation, with its vastly increased area of promised irrigation, is a much better vote getter than a much smaller "productive" system. Spreading the water (which is the essential objective of a "protective" system) also meant spreading the vote getting power of a limited supply of water.

In our analysis of tax collector and engineer interests at the local level which favored protective irrigation in the seventy five years before 1950, the rural vote factor did not enter in. After Independence the rural vote became a thing to deal with, and irrigation became perhaps the most important single carrot through which the rural vote was courted. Since the local politicians in the Post Independence period lived more indirectly off of taxes than the colonial tax collectors, it is understandable that they should seek new avenues to tap local rural surpluses.

31/ See Barve Commission op. cit. p. 61

Aside from exploring the extra-legal side of things, Wade has also written knowledgably about irrigation as a major element in the struggle for local political power. His analysis highlights the expanded political possibilities of protective policy. With the advent of pumping technology there are almost no voting constituencies that cannot be promised a protective system. A quote from Wade makes a good wind up statement on the local political potentials of the protective irrigation policy.

> "In large parts of India, irrigation can make the difference between subsistence and relative affluence. ... Hence politicians whose supporters live in non-irrigated, rainfall deficit areas, will do their utmost to secure an irrigation project, whatever its economic viability. Recently, with the familarity gained in lift-irrigation schemes (where canal water is lifted to higher levels by means of pumps), the room for this kind of pressure has greatly increased. Politicians, whose support base is in areas higher than can be irrigated by surface flow alone, can now press to have their areas included in a lift-irrigation scheme. In one northern state, for example, an already over-extended command area has been further extended by means of a costly lift-irrigation scheme to take water into the constituency of a politically powerful person in the state government; what is more, much of the water is being taken from the area of one of his main rivals. The economic assessment has been either irrelevant or has been adjusted to show the economic worthwhileness of the project. This is not an isolated example."[32]

c. Official Policy in the Planning Period: Obscuring the Protective/Productive Dichotomy

The officially apparent policy during the planning period (1950-1980) may be seen in the various five year plans and in the official irrigation commissions which deliberated during this period. There were six five year plans and a handful of national and state irrigation commissions. Both the plans and the commission reports exhibited a new thrust and flavor which was distinct from the commission reports of the earlier period. The most important difference lies in their obscur-

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32/ Robert Wade, **Performance of Irrigation Projects,** Economic & Political Weekly, January 17, 1976 at page 63.

ing of the distinction between protective and productive irrigation with the use of new terms such as "distributive equity".

The open frankness of the earlier commissions' distinctions between protective and productive are not to be found in recent reports. At times the documents talk rather directly about conflicting irrigation objectives, and at times simply contradictory positions are taken without apology or explantion. One has the distinct feeling of walking both sides of the protective/productive issue and yet keeping the two sides sufficiently separated that there is never any direct confrontation. The surface of the documents flows fairly well unless one stops to follow the implications of statements to their logical policy conclusions -- then the conflicts are obvious.

Aside from attempting to ride both the productive and protective horses at the same time in different directions, official policy began in the planning period to be flavored by what we shall term "irrigation panacea" thinking. Irrigation came to be thought of as the best solution to all rural problems and situations. Name a rural problem or rural area and the obvious answer to the problem was irrigation. This kind of thinking not only exaggerates the potential of irrigation, it can also injure policy regarding the proper role of rainfed agriculture and its proper place in the production of grains and livestock.

In the policy environment of "irrigation panacea" thinking which has emerged in India during the planning period, it should come as a shock to find that the record yield in wheat in the United States was not set under irrigation but was a dryland yield in a dry region (drought prone area in Indian terms). Eastern Washington, where this record was set looks arid even by Indian standards. Food grains are produced in the United States (in fact in most grain exporting countries) without irrigation and in many cases in relatively dry areas. A proper role of rainfed production and grazing is by no means ignored in India[33]. Yet the growing tendancy during the planning period to see irrigated agriculture as a panacea has

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[33]/ an example of the effort and thinking may be seen in the efforts of ICRISAT.

has hampered that thinking.

In many cases the best solutions, both for the poor inhabitants, and for the economy, may involve migration from lower potential to higher potential rural areas.- Soils, market accessibility, storage and conveyance sites, and other factors may make irrigation a poor investment in many areas whose proper role should be the production of low value grains or extensive grazing. Intensive agriculture is not the best solution everywhere.

The reluctance of politicians to see these realities, the persistent frankness of some irrigation commissions, and the unfortunate consistent resolution in practice by resorting to "protective" policy may all be inferred from the following quote from the 1972 Commission Report.

> "We were commissioned to make special proposals for irrigation works in the chronically drought affected and food scarcity areas. As we proceeded in our work we found that the difference between the chronically drought affected and drought affected areas was only one of degree. ...- Some areas of scanty rainfall ... must of necessity be devoted to sheep and cattle raising. When we posed the question to the experts of the Indian Agricultural Research Institute asking them what programme of irrigation they would suggest ... they readily replied: Leave them to sheep and cattle raising.'"

The close juxtaposition in succeeding paragraphs of drawing one conclusion, then responding to a political "requirement" which an opposite position in the commission report tells much about the inherent, but not directly confronted conflicts in irrigation policy during the planning period.

> "6. The concept of food deficit areas with the modern development of transport and communications has become irrelevant. It is not necessary for every area to produce its own food. ...
>
> 7. We were required to suggest the minimum works necessary for the drought affected areas to make them self-sufficient. Keeping in view the social urges and the demand for the removal of regional and social disparities which are basic to establish socialism, we decided that the development of irrigation in the drought affected areas should be the

maximum."[34]

Official policy as epxressed in the Irrigation Commission Reports of the planning period is essentially a juggling of "protective" and productive' policies without confrontation and the result is an obscuring of useful policy distinctions.

d. Irrigation Policy in Actual Practice During the Planning Period (1950-1980)

While the irrigation commissions of the planning period rode both the protective and productive horses, it would appear from preliminary reviews of a number of projects in a few states that the policy actually practiced was essentially "protective". Local engineers and politicians, however, usually use the newer terminology of "distributive equity". The design criteria used to determine the size of the commands resulted by and large in over-extended canal systems characteristic of the "protective" policy. A bias in favor of food grains still exists in crop pattern planning and administration in most states. The alternative of compact systems with a high value non-grains and perennial crop focus was the exception, not the rule. Actual practiced policy as found in the projects themselves, in design manuals and practice, and in administration is that side expressed in the following 1981 irrigation commission report.

> "In view of the limited surface water resources, it is now the policy of Government to reduce the area under perennial crops so as to secure dispersal of the irrigation benefits by supplying the same quantity of water over a large area." [35]

34/ Ministry of Irrigation and Power, Report of the Irrigation Commission 1972, New Delhi, page viii.

35/ Maharashtra Irrigation Commission, 1981

C. MAJOR PUBLIC POLICY ISSUES FOR SURFACE IRRIGATION IN THE EIGHTIES

1. Irrigation Policy in the Eighties and the Under-utilization Problem: Apparent Confronts Actual Policy.

As discussed above, irrigation commission and planning documents since independence have confused and/or obscured the conflict between protective and productive policies which was kept at the fore in pre-independence policy discussion. The result was an irrigation policy which held out hope for productivity and equity yet operated in the field according to the old "protective" policy standards which fails by either productivity or equity criteria. It was inevitable that the inherent conflict between the apparent productivity/equity policy, and the actual protective policy followed in the field would eventually come to roost. It was not so obvious, however, exactly how such a confrontation would appear. The place the two policies came face to face was on the rather unlikely stage of the "under-utilization" problem.

One of the expected characteristics of an over-extended canal system is a substantial excess of demand for water over the supply available. Small doses should at least make token coverages on large acreages. Even during the early planning period, there was gradually accumulating evidence that even the token coverage was not happening. An over-extended canal system designed to give small doses of water to 5,000 hectares for example, was found in practice to be giving doses to only 3,000 hectares. The design area of 5,000 hectares was called the irriga-

tion "potential"; the 3,000 was called the "utilized" area, and the difference was characterized as the "under-utilization" problem.

Irrigation commission reports of the sixties and seventies usually included a chapter which addressed the under-utilization problem, analyzed its causes, and proposed solutions. By the mid-seventies a general policy concensus had emerged about the seriousness of the under-utilization problem sufficient to spawn an official policy which was embodied in a new institution called the Command Area Development Authority (CADA). By the beginning of the 1980's it was becoming clear that the problem was persisting, even deepening, in spite of the CADA and other policies aimed at turning it around. The under-utilization problem has gradually stolen the whole irrigation policy stage, as the VIth Plan illustrates:

> "In spite of the large investment made in the irrigation sector and the phenomenal growth of irrigation during the past 30 years, the return from the investment both in terms of yields as well as finance are very disappointing. ... The reasons for this situation are many. The first and foremost is the delay in completion of schemes. Another reason is the delay in utilisation of the potential already created. In the context of delay in utilisation of irrigation potential and low yield from such areas, government introduced the command area development programme. The main aim of the programme is to reduce the gap between created irrigation potential and utilisation thereof and to optimise agricultural production."[36]

The growing concern surfaced by the widening realization of the dimensions of the under-utilization problem spawned a new round of Irrigation Commissions in the early eighties. Making clear their mission, the terms of reference of these commissions focused so exclusively on the utilization problem that these commissions may rightly be called, not general irrigation commissions, but "utilization commis-

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36/ Government of India, Planning Commission, Sixth Five-Year Plan 1980-1985, pages 149 and 157.

ions", and the policies they evolved as Utilisation Improvement Policy.[37]

The under-utilization problem and proposed solutions have so dominated irrigation policy and analysis in the eighties that I have devoted the entire section which follows to detailed consideration of that topic. Before passing to that section, however, it is important to put the under-utilization issue in what I think to be its proper context in view of the 100 year policy trends sketched in section B.

First, it should be noted that the issue is related by its terms to surface irrigation. For all of the attention it has recieved one should not lose sight of the fact that it applies to less than half of the existing irrigated area in the country, and only about one fourth of the value of irrigated production.[38]

Secondly, I am convinced that the under-utilization problem is the inevitable coming to roost of the inherent contradiction of expecting an over extended canal system, which is accompanied by restrictions on intensive crops, to behave like an intensive system with the productivity and equity benefits of intensive agriculture. For one hundred years, irrigation projects have been designed, constructed and managed along the lines of the nineteenth century protective model, even though official policy has, at the same time, emphasized productivity objectives and held out productivity hopes. Under-utilization in the eighties is the result of building one kind of system and expecting another kind of result. This obviously over-simplifies the problem, and we shall seek a fuller examination of the problem in the section which follows.

37/ see, Report of the Commission for Irrigation Utilisation, Syed Hashim Ali, 2 Vols. Government Secretariat Press, Hyderabad, Andra Pradesh, November 1982; and Report of the High Power Committee, Irrigation Department, Government of Maharashtra, November 1981.

38/ There is of course an "under-utilization" issue on groundwater, but it is not the same kind of under-utilization that is meant when surface systems are involved. There is an emerging concensus that ground water is the really large potential irrigation source for the future and in this sense it is under-exploited or under-utilized'. It is important, however not to confuse under-exploited groundwater with the "under-utilization" of already constructed surface systems.

2. Estimates of the Size and Trend of the Under-Utilization Problem.

a. Definitions and Concepts Related to Under-Utilization.

At its simplest level, under-utilization is a comparison of how much area systems have **historically irrigated** with the areas they were **designed to irrigated.** It is not a measure of productivity nor of equity since utilization does not not deal with yields, crop mix change, or with the final objectives of income and employment generation. It is, therefore, only the most minimal kind of evaluation criteria of the water delivery performance of an irrigation system.

For readers unfamiliar with Indian irrigation terminology, a paragraph of definitions may be helpful. The total area within gravity flow reach the canals of a system is referred to as the Command Area. The part of the Command which is cultivatable is referred to as the Cultural Command Area (CCA).Given limits on available water and terrain, only a part of the cultivatable land below the canals is actually intended for irrigation. The area which the system is intended to irrigate is called the Irrigable Command Area (ICA). Irrigation may be provided in three seasons (karif, rabi & hot weather). The term "net area irrigated" means area irrigated at least in one season. "Gross area irrigated" refers to the sum of areas irrigated in all seasons. Thus, one hectare irrigated in rabi and then irrigated again in hot weather would be one net irrigated hectare and two gross irrigated hectares.

The most common measure of utilization is a comparison of the number of gross hectares a system is designed to irrigate with the gross number of hectares it historically irrigates. Using net area irrigated would be simpler and, perhaps, fairer in the Deccan states. The reason for this is that irrigation systems in the Deccan are designed with a primary focus on rabi irrigation. It is somewhat unfair to fault projects for their failure to live up to the incidental intent to provide substantial karif supplemental irrigation. Making the utlization comparison on net irrigated area focuses the measure on rabi irrigation since that is the season in which the maximum number of hectares is usually irrigated.

The terms "under-utilization" and "field efficiency" are frequently, and sometimes deliberately confused. Engineers frequently refer to the "field efficiency" of an irrigation system, which means the proportion of the water in reservoir which finally reaches the root zone of crops. The field efficiency of a system is the way engineers discount the water available in the reservoir by a reasonable margin to arrive at the quantity of water which will be available at the field level to augment the water naturally available in the soil. Even the best irrigation systems do not get 100% of the water in the reservoir to the root zones of crops. Using an assumed field efficiency, engineers estimate the irrigable command area (ICA). It is important to remember that the ICA area to be irrigated (ICA) presumes an estimated level of losses of water between the reservoir and the field.-

For example, a system designed at 45% field efficiency to be able to irrigate 10,000 hectares, which irrigates 10,000 hecatares historically, would be termed 100% "utilized" even though 55% of the water in its reservoir did not get used by farmers for field irrigation. Engineers in India frequently suggest that Indian under-utilization is not really a serious problem by mixing the two concepts of "field efficiency" and "under-utilization".

It is sometimes said in defense of utilization rates in India, which average around 40%, that the field efficiency of model systems in the U.S. and elsewhere is no better than 40%. The engineers who make this argument should know the difference between a utilization rate and a field efficiency rate, yet for non-engineers the point seems credible. The systems referred to in the U.S. and elsewhere probably do have field efficiency rates under 50%, yet their utilization rates (the designed areas to be irrigated compared to the historical areas irrigated) are likely about 80%[39].

Table 1 presents acutal figures for two irrigation systems in Maharashtra to

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39/ The Andhra Pradesh Commission for Irrigation Utilisation properly refers to a U.S. Bureau of Reclamation study of several Western irrigation projects in which found a historical field efficiency rate of 44% and an implied utilization rate of 79.5%. See, S. Singh & R. Chander, Report of the Commission for Irrigation Utilisation, Government of Andhra Pradesh, Hyderabad, 1982, at page 49.

illustrate how these definitions work in real systems.

Table 1
Utilization Figures for the Ghod & Girna Irrigation Systems in Maharashtra

	Ghod	Girna
Cultural Command Area (CCA)	42,696 ha.	79,283 ha.
Irrigable Command Area (ICA)	24,948 ha.	57,209 ha.
Net area irrigated 1973-76	8,103 ha.	16,956 ha.
Utilization Rate	32.5%	29.6%

Sources: R. G. Patil, S.D. Suryawanshi, & P.M. Kapase, An Investigation into the Socio-Economic Conditions in the Ghod Command Area, Dept. of Ag. Econ., M.P. Agricultural University, Rahuri, Maharashtra, 1980, 174 p.; and R. G. Patil, S.D. Suryawanshi, & P.M. Kapase, The Socio-Economic Survey of Girna Irrigation Project Area in Jalgaon District, Dept. of Ag. Econ., M.P. Agricultural University, Rahuri, Maharsahtra, 1978, 229 p.

Both of these systems were completed in the mid-sixties and had been in operation for about a decade before the three year period included in Table 1. A review of rainfall figures for the past ten years in the project area indicates that the period 73-76 was a somewhat above average rainfall period. It would appear that these two systems are irrigating about one third of the net area they were designed to irrigate. In the terms developed above, this implies an under-utilization of about 66%.

b. Estimates of the Size of the Under-Utilization Problem.

The most systematic state-wide analysis of the problem I am aware of to date, is the 1981 Maharashtra Utilisation Committee report. That report summarizes the average utilization on major and medium projects at 46.1% and on minor projects at 30.9% in 1979.

There are other attempts at estimates which are for particular projects but lack the global coverage of the Maharashtra estimates. In 1977 the Comptroller and Auditor General published a report in which utilization rates were estimated for 12 large projects for the period 1971-76. The variation was large, as described in the following review of the report:

> "Taken together, these (12) projects were expected to irrigate 6 million hectares ... Full or nearly full utilisation of potential was achieved only in the Haryana and Rajasthan segments of the Bhakra Nangal project and in the Hirakud project in Orissa. The level of utilisation was tolerable in the Sarda Canal System (UP) and in Mayuakshi (West Bengal). In the rest (8) of the projects the average utilisation was no more than 42 percent and it was as low as 18 percent in the Kosi Eastern Main Canal and Raipur Branch Canal in Bihar." [40]

If the state-wide data, from Maharashtra is compared with the rough average of the Comptroller's review it would appear that 40-50% might be a reasonable estimate of utilization for India as a whole. A reasonable estimate for the Deccan states would be about 40%.

It is important to remember that utilization is not a measure of the productivity of a system, it is really a measure of its "protectivity". Under the protective policy prevailing during the last century, most systems have been designed to spread the water over the maximum area possible in the smallest doses reasonably possible. Therefore, the area they actually reached by irrigation is no measure of how productive the system is. The area actually reached is only a measure of how the system functions protectively, ie, how much area is protected, or protectively irrigated.

In one sense the utilization measure is a fair one, it measures protective systems against their correct objective-- protectivity. It measures the area given at least some water, at least occassionally. The evaluative result of the under-utilization debate is essentially the same one after 80 years of experience (1900-1980) as the one the commission reached in 1900 after 25 years of experience

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40/ For Whom the Water Flows, Review of Agriculture, Economic and Political Weekly, March 1978 p. a-1

(1875-1900). That conclusion is that protective works perform poorly even from the view of protection.

It is not easy to reorient policy debate in India from the protectivity focus of the utilization issue, to the more important issues of system productivity and equity. The fact that policy discussion has focused on utilization as opposed to un-productivity or inefficiency may have something to do with the fact that engineers continue to dominate the debate. An engineer's view of irrigation focuses on water delivery, rather than on the final effects of irrigation as Wade observes:

> "A further significant feature of irrigation projects is that engineers dominate in their design and operation. ... Today one of its consequences is that irrigation engineers tend to view the output of a canal system as **water**, not the additional crops which that water should allow."[41]

The utilization problem is an engineer's way of viewing the issue, since it begins and ends with the "water" output and does not reach on into the agricultural result. Together, these two viewpoints, (the engineers' focus on water delivery and the protection bias), have cast the current policy discussion on just the issues it should be drawn away from if real productivity are to result. The utilization problem is an interesting symptom, it does at a bare minimum suggest that protective systems are poor protectors. Yet the utilization issue is not the real issue. It diverts attention and resources from final productivity and agricultural intensity, which, in the end, provide the poor with remunerative employment and income; these are their only real protection.

41/ Wade, Performance, op. cit.

c. Recent Trends in Under-Utilization.

The only data set I found which provided a reasonably reliable trend in under-utilization is that provided by the Maharashtra utilization committee. Their data show a fluctuating yearly pattern with a gradual but irregularly decreasing trend. This trend starts in the late sixties at about a 55% utilizsation rate and decreases to about 45% by the late seventies. It appears from this data that the problem is getting gradually worse.

3. Major Hypotheses about the Causes and Solutions to the Under-utilization of Surface Irrigation Capacity.

While admitting that utilization is not the right issue to focus on, I recognize that it is the issue which currently holds center stage. I feel that adequate analysis of this issue will lead eventually (though somewhat indirectly) to the important underlying productivity and equity issues. Therefore, rather than trying to re-orieint the current popular exploration, it seems more helpful simply to follow its logic and try to carry the exploration to it's productivity and equity conclusions.

As one might expect, from an engineer's point of view, under-utilization would probably be seen as a lack of construction and related failure in the water delivery system. Hence, the first and most common cause of under-utilisation has been identified as the delay in completing canal construction to the farm level.- In the VIth Plan the most important reason for under-utilization is determined to be that:

> "In most of the projects there has been delay in construction of field channels and water courses, land leveling and land shaping."[42]

42/ Government of India, Sixth Five Year Plan 1980-1985, Planning Commission, New Delhi at page 149.

Lack of construction of field channels below the traditional government outlet is cited in most diagnoses of the causes of the utilization problem as the predominant cause. In addition to the predominant "field channel" hypotehsis there are a handful of other often cited causes. The fact that under-utilization has continued high even after field channels have been constructed has led to the suggestion of other possible causes. The most common suggested causes of under-utilization may be grouped as follows in approximate descending order of the frequency of their appearance in government reports. The most often proposed solutions are included in parentheses:

1. Lack of field channels and land shaping (construct channels)
2. Lack of coordination at the project level (establish CADAs)
3. Lack of adequate on-farm water management (train farmers)
4. Lack of farmer participation in system design and O&M (organize farmers)
5. Lack of marketing, processing, & transport infrastructure (construct facilities)
6. Lack of agricultural credit and production inputs (provide credit & inputs)

These possible explanations are not really separable. The obvious inter-relationships, however, do not prevent us from slicing into the problem from one of these directions. Analyzing the field channel hypothesis first leads to consideration of the issues in a helpful sequence.

a. Analysis of the Field Channel Hypothesis.

The 1981 Maharashtra utilization commmittee discussion of the field channel hypotehsis provides an adequate train of thinking to puruse in this analysis. The committee first reviews the statistical evidence of the size and trends in utilization, concluding that it is a large problem and one which has worsened in the last decade of the seventies. Immediately following the finding of a deteriorating condition, the committee turns its attention to a section entitled "Causes of Under-Utilisation and Measures to Ensure Full Utilisation" and discussion of "Measures Taken So Far for Stepping up Utilisation":

> "The Committee was pleased to note that the Government has taken various steps and measures (as enumerated below) for stepping-up utilisation of the Irrigation potential during the last decade. The main bottleneck in fuller utilisation

was the lack of response from the farmers to come forward for construction of field channels beyond the outlet."

Why the committee was "pleased" with the treatment applied during a decade when the illness was observed to worsen is puzzling.

Before finishing the Committee's chain of thinking, it is useful to understand the committee's suggested "main bottleneck". Notice that the committee not only identifies the construction of the field channels as the primary bottleneck to full utilization, but also correctly assesses **why** they were not constructed. The committee states that farmers did not "come forward". This is a way of saying that the farmers were not pushing for field channel construction, nor would they undertake it on their own. It should be remembered that before 1970, farmers were responsbile for constructing the field channel from the government outlet to their individual fields.

A key question the committee should have been asked at this point, but did not is: why were farmers uninterested in digging these relatively short dirt ditches to get the water to their plots?. That question would have led them to a valuable understanding of the real problems which lay behind the utlization issue-. Instead of examining possible reasons for a lack of farmer response, the committee proceded to discuss the government's solution.

> "In absence of such a response, Government initially undertook to construct water courses on behalf of the beneficiaries under the Land Improvement Schemes Act and treating the expenditure as a loan to the farmers. ... Thus the Government has taken over full responsibility for carrying out this work ... (in addition) Concessional water rates are being charged in the initial years of commissioning of the projects so as to induce the farmers to take water."[43]

The committee report accurately admits that government was faced with "inducing" the farmers to take the water.

Why didn't the engineers and planners ask themselves searchingly why, in such apparent dire need of water, are'nt farmers interested in taking it? Why did'nt

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43/ High Power Committee p. 10

they ever wonder if the farmer had good reasons for his frequent disinterest, and if the farmer's reasons had something to do with the conditions under which the water was being offered to him? Rather, the committee concluded (as have most engineers) that the farmers must be "induced" by additional government construction and concessions to "please take the water".

An alternative hypothesis is that farmers are unable to make profitable use of the water offered under conditions implied by an overextended canal system and crop restriction procedures. Since they can't make money on the water they are unwilling to spend their limited resources to get it. Another way of saying this is, simply, that farmers have great difficulty getting profits or productivity out of protective irrigation. Wade helps us to understand why the engineers reached the conclusion that farmers were acting irrationally and needed someone to do the engineering and construction for them:

> "...they (the engineers) tend to see poor utilisation of water by farmers as a demand problem, not a supply problem. They tend to explain unsatisfactory performance of a scheme in terms of the "backwardness" of the farmers... "[44]

The opposite hypothesis is that farmers' reluctance and the resulting under-utilization of offered irrigation water are rational given the conditions under which water is often offered in protective' systems. In analyzing this hypothesis we must remind ourselves of the unique elements of a protective system and how these effiect the conditions on which water is offered. The two elements of a protective system are an overextended canal system, and crop restrictions. First I explore how an overextended canal system affects the conditions on which water is offered, and then examine the effect of crop restrictions.

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[44]/ Robert Wade, **Performance of Irrigation Projects**, Economic and Political Weekly, January 17, 1976.

b. Implications of an Overextended Canal on the Conditions on Which Water is Offered.

The main effect of overextending a canal system beyond the reach of its water is to make the deliveries both inadequate in quantity and make the delivery schedule unreliable. The farmer is offered water under the dual conditions of insufficiency and unreliability. The bottom line for the farmer in a protective system is well outlined in the Andhra Pradesh utilization commission report:

> "The net result is that long stretches of main canals, distributaries, and minor canals are built which do not receive any water at all or if they do, the supply is very inadequate and not enough for the growth of the crops planned. Such an extension of the canals is sometimes done for political reasons as well, when farmers lower down in the system demand water and to satisfy them a canal system has to be built."[45]

If insufficiency was the only negative condition under which water was offered in protective systems, farmers could adjust to that reality and make rational income maximizing use of the small but reliable supply of water. Unfortunately insufficiency of supply is also accompanied in protective systems by unreliability. The farmer cannot count on the water on the day it is needed.

It appears that lack of reliability is even more of a problem than lack of quantity. From my own field visits and from the data I have reviewed it appears to me that farmers will undertake considerable self-help efforts, such as the construction of field channels, to get at even small supplies of water they believe will be reliable. My own finding appears to be supported by Pant's analysis:

> "An intersting observation made by the author during the recent visit (1981) to the Kosi region was that in several areas where the farmers had some assured but not abundant water supply, the cultivators had made their own field channels. However, their main grievance was against unreliable water supply. Therefore it is not true that the farmers are not willing to con-

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45/ Andhra Pradesh op. cit. p. 69

struct field channels on their own."[46]

Water reliability is at the heart of the inherent conflict between protective and productive systems. All crops are not equally sensitive to water reliability. Those crops which are less sensitive are not, surprisingly, the lower value grains crops. To be sure, the yields of even the drought resistant grains crops can be increased if given a reliable supply of water. The yield increasing potential of irrigation on grains may tempt a water scarce country into putting its water on grains as evidence by the Green Revolution in India. Yet, the principal way to make money from irrigation, which most farmers understand well, lies not in getting better yields by watering low value grains crops, but in making the switch to the higher value crops. Without a reliable water supply farmers cannot make the switch because the higher value crops are not resistant to the stress of unreliable water supplies. Grains are stress resistant and will do pretty well without irrigation, and somewhat better with an irregular supply of irrigation. However, without reliable water it is simply not possible to make the switch to the better income provided by the stress sensitive crops. Wade has stated this axiom as follows:

> "Without water, a switch from stress-resistant but low-income crops to stress-sensitive but high-income crops is simply not possible.[47]"

Readers who have farming experience with irrigation will find Wade's point to be an obvious, almost trite statement. A sentence or two will help to explain the idea to non-farmers. If a farmer fails to water his wheat this week it may hurt yields some but the wheat will do fairly well if it is watered within a week or two. On the other hand, if onion starts are not watered this week they will

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46/ Niranjan Pant, Utilisation of Canal Water below the Outlet in Kosi Irrigation Project. Economic and Political Weekly, September 1981.

47/ Robert Wade, Performance of Irrigation Projects, January 17, 1976 Economic and Political Weekly

die. If a farmer is using Indian technology he can get about Rs. 2,000 from my hectare of jowar if it is irrigated medium well or Rs. 3,000 if irrigated well. He can get Rs. 12,000 from a hectare of well irrigated onions and nothing if he misses the weekly irrigation of the onion starts. There is also a seasonal availability issue discussed below which affects high value perennial crops such sugarcane or citrus.

Reliability is the key to making irrigation productive, not government construction to "induce" nor organizations to train farmers to use an unreliable supply. Lack of farmer interest in unreliable irrigation water is evidence that the marginal productivity and profitability of unreliable water is not sufficient to cover the costs of channels and land shaping to obtain and make use of it.

c. Implications of Crop Mix Restrictions on the Conditions of Water Offered in Protective Systems.

In addition to the problems of unreliability and insufficiency of water supplied by protective systems they also restrict to some extent the crops farmers can grow with the irrigation water. One way to ration insufficient water supplies is to restrict the crops farmers grow to those with low water requirements. These low water crops are the food grains, and were called "dry food crops" by the 1901 commission, and were characterized by Wade as "stress resistant but low income".[48]

The attempt to restrict cropping patterns (except perhaps in the case of paddy) flies directly in the face of the most important source of productivity and equity, which comes from a switch from stress-resistant but low income crops (the grains) to stress-sensitive but high income crops (everything but grains). It is a contra-

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48/ Irrigated paddy rice is the one foodgrain that does not fit the characterization of low stress and low income. However, in the Deccan, only a very small percentage of the rice grown is irrigated. Thus the generalization made by Wade fits the Deccan even for rice. In many areas of Eastern and Southern India Paddy has the unfortunate characteristic of high water demand uncharacteristic of grains but without the high incomes characteristic of the non-grains crops. This situation has led to the restriction of paddy cultivation in many irrigation systems.

diction in terms to expect productivity and profitability from an irrigation system and at the same time discourage the very cropping patterns that are the central route to productivity and profitability. Yet this is exactly what was done during the planning period through the combination of factors associated with protective irrigation policies.

d. Seasonal Restrictions and Unreliability in Protective Systems.

Protective systems also generally impose restrictions and unreliability on the seasons availability of irrigation water. The famine protection origins of the policy led designers to view the systems as supplemental to rainfall. Their interest was in providing water in the event of irregular monsoons. This bias carried over into modern times in the form of large planning allowances for karif irrigation, and limited, or even prohibited supplies for hot weather irrigation.

The way irrigation planners sought to distribute water seasonally conflicts fundamentally with farmer's interests in productivity and profitability. Irrigation water is more profitable during the water scarce rabi season, and most profitable during the hot weather season. Part of the high profitability of water during the hot weather season is due to the need to sustain high value perennial crops through the summer. By planning for large karif irrigationss when the profitability is lowest, and restricting or prohibiting irrigation during the hot weather season when it is highest, protective policy works against productivity and equity.

The very large disinterest of farmers in karif irrigation, (when over one third of the water from protective systems is to be provided), and the very strong interest in summer, should have told the utilization commissions much about the inconsistent fashion in which protective systems seek to deliver water. The Maharashtra utilization committee made the right observations, but drew the wrong conclusions as follows:

> "Of the total potential created in the plan period, nearly 35% is expected to be utilised in the Kharif season. ...the tendency of the cultivators, is generally, to wait for the rains ... this largely contributes to the

over-all short fall in untilisation mainly in the Kharif season. In a number of projects the traditional crops envisaged in the project report are being replaced ... These varieties need more water than the traditional crops envisaged ... Although the water is consumed, the area apparently appears to be lower. So far as hot weather is concerned there is no difficulty (no lack of demand for the water) as in Hot Weather mostly cash crops like groundnut, vegetables etc. are grown. The Committee observed that the demand for such cash crops is spread over a large area and sometimes at the tail end of the canal and distributories."[49]

Protective systems offer irrigation water to farmers with four important "strings" attached: (1) The quantity supplied is generally insufficient to support high value and high employment crops, (2) The supplies are unreliable, a farmer can seldom count on getting water at a particular time, (3) The crops the farmer can grow with the water are restricted, and (4) The water is supplied in seasons when it is not profitable, and not supplied in the seasons when it is most profitable. To the degree that these conditions are enforced, they put important limits on the ability of farmers to make profitable use of the water.

4. Under-Utilization Isn't as Bad as it Appears; It is Evidence that Poor and Rich Farmers Alike Are Trying to Make Protective Irrigation Systems Productive

The title to this section is as overextended as a protective canal. I apologize for that, but it makes my point. Farmers, poor and rich alike, have tried hard to get the best they can out of a difficult situation. In their legal and extra--legal manueverings they have tried to get the most productivity out of the systems they have been presented with, and part of the result has shown up as under-utilizsation.

In order to analyze the process by which farmers attempt to make a productive system out of protective one we must get the definitions straight again.

First, protective systems have canals which extend over a much larger area

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49/ Government of Maharashtra, Report of the High Power Commission, 1981 at pages 9 & 20.

than can be supplied reliably and frequently with water. A productive system has a smaller compact canal system and reservoir which is designed to provide reliable and sizeable water supplies to a smaller area.

Secondly, a protective system restricts the cropping pattern adminstratively and/or legally to bias it in the direction of low-water-low-income crops (the foodgrains). A productive system has no restrictions on what crops can be grown with the limited water the farmer is assured.

To change a protective system to a productive one, one would reduce the reach of the canal system and remove the crop restrictions. That is precisely what farmers have done with protective systems to the degree they had the power to do so. Before passing to an examination of the evidence and implications of this result, it is very important to note that the effect of these "productive" changes is to cause "under-utilization". Since under-utilization is the difference between planned area irrigated and actual area irrigated, to concentrate the water on small areas will decrease "utilization".

a. Reducing the Effective Size of Protective Commands.

First, we examine how farmers have effectively reduced the size of the canal system in protective systems, thus making them simulate or act more like productive systems. The most obvious way this is done is for the head-enders to take all (or disproportionatly large shares) of the water. There is a simple way of saying this: build a canal too long for its water and it will be shortened in practice. If it takes a long time to build the canals this practice is facilitated. Wade outlines this common practice as follows:

> "Commonly, farmers in the head reaches are allowed to take water while the canals further down are under construction. They, therefore, have ample water in this initial period and adopt water intensive cropping patterns. When the lower reaches are ready, they mount intense resistance to the consequent reduction in their water supply. This has been a particular problem of canal schemes in drought-prone areas, where the irrigation policy aims to spread water over as large an area as possible ---

and in that sense is protective.[50]

The same thing happens even if the canals are built rapidly. Farmers have other ways to keep the water flowing if they have the money or power to do so:

> "...there is room for considerable discretion in dispensing or withdrawing costs and benefits. Any irrigation farmer will know who he has to bribe, and how much he has to pay in order to get the sluice raised by another few inches,.."[51]

Before passing to an analysis of who benefits in the short and long run from these distortions, (poor farmers, rich farmers, and irrigation administrators) we should note that the effect is to reduce the spread, effectively shorten the canal and bring the effective command size closer to what it would have been if it had been designed after the productive policy in the first place. The second result of these field realities is to make the actual area irrigated substantially less that the design area; hence, it will show up in the numbers as "under-utilization". It should also be noted that a long dry canal is wasted concrete and a lot of hopes raised and dashed. There is obvious tragedy for the poor in a dry canal, but it may not be so obvious that the tragedy cannot be averted by enforcing sluice openings and closings through warabundi. The problem is deeper than that.

b. Evading Crop Restrictions.

Farmers have also tried to defeat the crop restrictions which have come in the train of protective irrigation. Farmers know that if they can grow stress sensitive, water-using and high-value crops they can make money to protect themselves in lean times. A productive system is designed to facilitate and support this kind of real protection, a protective system one only hampers, and prevents it.

50/ Wade, Performance of Irrigation Projects.

51/ Wade, Performance of Irrigation, op.cit.

It isn't hard to see how farmers get around the restrictions and try to protect themselves. Wade states it simply and directly in the continuation of his above cited quote:

> "..there is room for considerable discretion in dispensing and withdrawing costs and benefits. Any irrigation farmer will know how much he has to pay to have the fact that he is growing (a restricted crop) where he should be growing a crop which requires less water overlooked."[52]

The result of the farmers' successful efforts to remove crop restrictions is to make a protective system behave more like a productive one where there are no crop restrictions. It will also appear in the numbers as increased under-utilization because the water will be used in smaller areas in higher value crops. This increased value and employment is what productive irrigation is all about and productive systems are designed to facilitate and support it -- protective systems to hamper and prevent it.

Wade is not simply talking about exceptions, farmers have been successful in moving protective systems a considerable distance toward productive ones. Their evasion of crop restrictions are a major factor in the under-utilization figures as noted in the Comptroller General's report:

> "Some of the other reasons (besides lack of field channels) for the low utilisation of irrigation potential disclosed by the Comptroller and Auditor General's study are of particular significance. There were large-scale violations of the prescribed cropping pattern and unauthorised cultivation of water intensive crops..."[53]

52/ Wade, Performance of Irrigation Projects, Economic & Political Weekly January 17, 1976.

53/ Editor of the Review of Agriculture, For Whom the Water Flows, Economic and Political Weekly, March 1978. Readers should be reminded that paddy may be an important exception to the general situation in which crop restrictions are counter-productive for reasons explained above.

c. Groundwater: Escaping Crop Restrictions and Obtaining Reliable Water.

Farmers have used a third general approach to get around the inefficiencies of protective systems which has nothing to do with the emulation of a productive systems. Farmers simply wait for the water from the surface canals to enter the ground and obtain it from a private well. This is perhaps the commonest, and certainly the most effective method of getting around both of the major defects of protective systems, un-reliability and crop restrictions. The widespread use of-private wells to use canal seepage may be the most important productivity and equity impact of surface systems. It should also be noted that if a farmer chooses to ignore canal water and take it after it enters the soil as groundwater, his choice will show up in the numbers as under-utilization of the surface system.

In summary, farmers are effective in undoing some of the characteristics of protective policy and making protective systems behave or operate in some senses like productive ones.

d. Assessing Gains and Losses from Farmer Modification of Protective Systsems

In this subsection I try to estimate what is lost or gained when farmers modify protective systems through the three processes outlined above. I also assess who loses and who gains.

Some losses relate to how much cheaper it would have been to build smaller more compact or productive systems in the first place, rather than to indirectly make a large one behave small. The money spent on dry canal and extra dam capacity could have been used to finance other more compact systems. There is the obvious net loss to the rural population (though not necessarily to the economy) of the bribes it takes to make the system smaller and less crop restrictive. Both of these two losses are bourn by the rural poor. The construction people are left about the same in both cases, they are not really affected by whether the canals carry water or not. Irrigation officials and local politicians are obviously better off with a system that opens up opportunities for their discretionary and expen-

sive "informal" collaboration. The protective systems are protecting someone after all.

The more important questions of distribution of benefit and loss relate to the small farmers and landless laborers who were supposed to be protected. It is here that the calculus become more difficult. The computations required to trace the productivity and equity differences and how they appear to be distributed between the poor and the not-so-poor are beyond the scope of this document. These issues are treated in more detail in another paper.[54]

To assess the impact of irrigation on the poor, it is important to realize that small farmers are neither the largest poor group nor the poorest group in rural India. Landless rural families are both poorer and more numerous than small farm families. When we are assessing equity impacts of alternative irrigation policies, the impact of irrigation on rural employment, (which is the place irrigation and the landless meet), is even more important than impacts on farmer net incomes.

e. Illustration of the Impact of Irrigation on Employment and Income on Small Farmers and Landless Laborers.

This subsection presents an illustration of the interaction between the major variables in protective and productive systems, and how these variables effect the employment and income of small farmers and landless laborers. In this illustration we compare using one hectare meter of water to irrigate a hectare of citrus on a large farm near the head end of a canal, with irrigation of two hectares of jowar on a small farm at the tail end. To exaggerate the policy meaning of our example let us assume that it takes four times as much water to supply one hectare of citrus year round than it takes to water jowar in one season. If it takes 1

54/ S. Daines, Productivity, Equity and Economic Issues for Irrigation in India., Appendix E, Irrigation Sector Evaluation and Strategy Review, USAID India, SRD Research Group, Logan, 1985, (Prepared under subcontract to U.S.U. WMSII Project, Consortium for International Development)

HaMT to support one hectare of citrus then the same quantity of water should water 4 Ha. of jowar, but since the small farm is at the tail end we will assume that half of the water is lost to seepage. Let us assume a healthy yield increase on the jowar in the small farm which would raise the income of the farmer from Rs. 1,000 per hectare to Rs. 2,000. This would mean that the water if used at the tail for the small farmer's jowar, would result in an increase in income to the poor farm category of Rs. 2,000. Now, returning to the large farmer at the head end, let us assume that without water he would have grown jowar and obtained the same dryland yield as the small farmer, or Rs. 1000. With irrigation the value of the citrus production minus payments that go out of the region in fertilizers, power, chemicals etc. will be about Rs. 15,000. The net increase is Rs. 14,000 above the dryfarm jowar alternative, but -- who gets it?

To answer this question and to enter the landless rural poor into the picture, let us assume that a landless family is living close to the small farmer at the tail end of the canal. Irrigation on the small farm would increase the yield in jowar substantially, and perhaps increase the number of person days required from 30 person days per hectare (60 days for the two Has.) without irrigation to 40 days per hectare (80 days for the two Hectares.) If we add in about 2 days for off-farm labor in transport and processing for the marketed part of the jowar we have about 84 total days. The small farm family itself has four workers and can not only handle the labor needs of the irrigated jowar, but join the landless family for most of the year looking for employment elsewhere. Irrigation on the small farm benefitted the small farm family by Rs. 2,000 but did nothing for the landless.

The citrus story, however, is a different story, and that story is essentially the story of "intensive" market oriented agriculture. Without irrigation the hectare at the head end in the large farm would generate the 30 days employment. The large farmer's family can easily supply this labor, no wages are paid to landless workers. With irrigation, the citrus requires some 600 person days of labor, bunched mostly during the short harvest period. Because the labor is bunched the large farmer's family can supply only a small part of this labor -- say 100 days -- the other 500 days must be contracted. In addition, there are some 100 off-farm

labor days required to pack, transport, process and market the citrus. This will be paid to hired labor in towns and will draw largely from the landless poor.

Table 2 presents these accumulating figures. To convert person days into money I assume a wage rate of Rs. 15/day. In the event citrus is grown, the large farmer has gained a large profit after labor and other out of pocket costs. The profit is around Rs. 6,500 on just one hectare and a net increase over his unirrigated alternative of Rs. 5,500. The landless rural labor class have gained 600 days at 15 Rs. or Rs. 9,000.

From Table 2 notice that the poor group, including the landless and the small farmers, get more money from the large farmer's citrus than from the small farmer's jowar crop and the margin is large. Four and one half times as much income comes to the poor from the diversion of water to large farm citrus and away from the small farm jowar. We should also note that all of this income goes to the lowest income strata since small farm families are considerably better off than the landless.

Now let's add the next realistic wrinkle to the analysis. Let us assume that the small farm family has four workers and, therefore, 1,000 labor days of available labor. His jowar, even if irrigated will only absorb 84 of those days and so 90% of the year his family are like the landless laborers, looking for work. It would not be unusual at all for his family to migrate to the town at the head of the canal and work during the citrus harvest. If the four of them worked one month in the harvest and two weeks in the packing-processing citrus, they would make more wages there than they would make in income the rest of the year on their small farm from the cultivation of jowar.

The large farmer also makes a lot of money from the diversion of the water to his citrus plantation -- almost five times as much as he made without irrigation.- The illustration, so far, reminds us of the quote cited above from the 1901 & 1938 irrigation commissions:

> 'The Irrigation Commission (1901) was disposed to doubt whether (the protective) system of administration had any real advantage even from a protective point of view. ... What is really wanted is remunerative agricultural employment of the people; as long as this can be found for them by means of irrigation

works, it is a matter of little importance whether they are employed in the cultivation of food crops or of such a crop as cotton or sugarcane. ... the best protection a canal can give is afforded when the supply is used from year to year to obtain crops of the maximum value..." (op cit.)

The commission is essentially correct because of the corresponding high labor requirements that accompany all high income crops. This concurrence of high income and high labor requirement assures that while the growers and processors of these products will likely reap large profits, cultivation of high employment crops will also result in very large labor payments to otherwise unemployed and poor landless families.

Table 2
Illustrative Example of Protective vs. Productive Irrigation and Impacts on Income of Farmers & Landless Laborers

Economic Group	Increased Income from Water Used:	
	In Small Farm Jowar (Protective)	In Large Farm Citrus (Productive)
	Rupees	Rupees
Large Farmers	0	5,500
Small Farmers	2,000	0
Landless Poor	0	9,000
Total Poor Income	2,000	9,000

From our example it can be seen that the bottom line for the poor (landless and landed) depends on the employment and income generation numbers for different crops. It is because these numbers are not carefully taken into account that the stark contrast between protective and productive systems is seldom confronted. Our simple example above is by no means the only possible result. There are some exceptional situations where the poor as a group are prejudiced by productive sys-

tems, but the analysis I have conducted indicates that these are exceptions and not the rule. The analysis reported in another paper[55] was used as the general basis for selecting the numbers and magnitudes in the citrus/jowar example above. I believe the illustration to be broadly representative of most crop options which characterize the choice between foodgrains and stress-sensitive high-value crops.

The illustration fails to account for the costs of "informal" encouragements which the large farmer had to pay to get the water diverted. Since these informal payments constitute a transfer from the large farmer's profit pool of Rs. 5,500 and is, therefore, a transfer from the rich to the rich. It does represent a loss to society in that it will not generate taxes, nor will it likely be donated to build more irrigation systems. "Informal" income may trickle back into the economy or be lost through imported luxury consumption, but it is a moral and economic loss anyway it is counted.

Distributing water to large numbers of scattered citrus plantations on small farms would result in large loses through canal seepage. The water lost implies that smaller total areas of intenstive crops can be grown if the plantings are dispersed. The poor as a group would be substantially prejudiced by the smaller areas in intensive crops which would result from dispersion since there would be less total employment generated from the same scarce water supply.

The added small farmer income which would result from dispersion, is likely to be more than offset by the added labor share of landless laborers gained from concentration. The distributive choice, sometimes called social justice, which the protective policy is forced to take, prevents these productivity factors from excersizing their force. We can see this expressed in the Maharashtra Utilizsation" Committee report:

> "The Committee, however observed that the deamand for such cash crops is spread over a large area and some times at the tail end of the canal and

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55/ Daines, Productivity, op. cit.

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distributories. If all the demands are to be satisfied, it will result into heavy transit losses thus reducing the utilisation. Although social justice demands that the available water should be distributed equitably, from the interest of the State as a whole, it is desirable that the area to be sanctioned is concentrated so that with the same quantity of water larger area can be irrigated. However, in the present context, Social justice will have to override the other considerations and as such we recommend that cash crops should be equitably distributed."[56]

Building compact systems in areas where small farmers predominate would accompish the best possible balance in equity and productivity objectives. In that situation the Rs. 5,500 in large farm profits shown in Table 2 would go to small farmers.

If the grains cropping pattern caused by protective systems were to function as protective systems intend, the poor would reap neither the labor nor the profit benefits of the irrigation induced switch from low-value to high-value crops. This is the first disadvantage to the poor of protective systems. The second disadvantage arises in protective systems which have been extra-legally modified to perate partly like productive systems. In this case, the poor are able to get at one part of the benefit (labor share through off-farm employment) but are not able to capture any of the profit share in the switch to high value crops. This is because of the simple fact that they have little extra-legal leverage to make the switch happen on their properties in competition with the large farmers.

It is in this respect that extra-legally modified protective systems are substantially less equitable than systems designed from the start as productive systems. The poor have a much harder time competing in a situation where "informal" leverage is the source of both irrigation reliability and crop pattern priviledges -- the poor have little margin above survival to use as leverage. This is not to say that the poor never bribe or are without any leverage. There are substantial acreages of prohibited crops on small farms and it is likely that those who control water supplies have found "informal" ways to tap their surpluses, however meagre

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56/ See, Government of Maharashtra, The High Power Commission, 1981 at page 20.

they may be.

The final way in which the poor are prejudiced by protective systems (even if extra-legally modified) is that they might have been the beneficiaries of the compact productive systems that were not funded because of the money wasted on empty canals and oversized dams.

5. Markets and Marketing: The Principal Non-Water Constraints on Productive and Profitable Irrigation.

The above discussion may leave the impression that reliable water is felt to be the only serious constraint which limits the development of fully utilized and productive systems. The data and literature I have reviewed does seem to point to water reliability as the prinipal part of the explanation of both under-utilization and the lack of income and employment generated by irrigation in India. But there are obviously other factors, the most important are marketing and market demand constraints.

The income and employment impacts of irrigation depend largely, as we have outlined above, on the degree to which the cropping pattern makes what Wade calls the "switch" to high value and high labor crops. High value and high labor crops are of many types, most of which are also more "marketing" intensive than the low value cereals. Citrus, bananas, potatoes, onions, vegeteables, other tree fruits, grapes, and flowers are all highly perishable in comparison to grains. A functioning marketing channel must exist before these crops are grown, even if there is a stable water supply. Other high value crops such as sugarcane and cotton which are not perishable depend instead on the existence of processing facilities.

Desarda, in analyzing the major factors responsible for under-utilization, focused on "institutional" problems, and, more importantly, on access to marketing and processing "supportive" systems:

> "...irrigation creation has been coupled with a sizeable under-utilisation of the already created irrigation potential. Utilisation ranges between 20 and 70 per cent of various projects in a large number of states. Yet the reasons for the low utilisation are primarily institutional ... and

still more in access to credit, processing, marketing and other supportive services."[57]

It is not easy for irrigation engineers to understand or accept the simple point that the establishment of a processing-marketing system is probably the most significant thing that can happen in an irrigation command to make it fully utilised and productive. In fact, if a processing facility is constructed in an irrigation command, it is powerful enough to undo almost all of the engineers efforts to make the project protective. Wade explains:

> "In one large southern scheme ... most significantly for the future of the project a cane factory has now been established. ... once a factory is in operation ...it (is) very unlikely that farmers will be prevented from continuing to grow sugarcane. If this is the case, then the total command area of the project will be significantly less than planned...- This would show up in statistics as another case of underutilisation."[58]

In addition to the constraint imposed by the lack of marketing and processing infrastructure and commerical institutional linkages to make them work, there is the other factor of limited market demand. The market demand for non-grains products is growing faster than grains demand in India, yet there are still important limitations on the total consumption demand. These market demand constraints would prevent unlimited expansion even if export markets were also tapped. It appears, however, that the current limiting factor is marketing and not market demand.

Engineers and other irrigation experts are often reluctant to concede that a factor as far afield from their area of expertise as marketing could be the major factor constraining the success of their projects. Their reluctance to accept this fact is perhaps an unimportant critisism, even if they accepted it they would be unable to affect it, as the review of the CADA experience below indicates.

57/ H. M. Desarda, **Irrigation: Winking at Water,** Economic and Political Weekly, July 1983 p. 1852.

58/ Wade, Irrigation Performance, op. cit.

6. Summary Review of the Major Factors Apparently Contributing to Under-Utilisation of Surface Irrigation Systems.

From the data and literature available to me, we have concluded that among the many potentially contributing factors causing under-utilization, the three that stand out as the most probable are:

1. The extra-official modification of protective systems through the growing of unauthorized crops and the un-anticipated increases in the intensity of irrigation through head-end and other extra-official diversions. These are not really water wastage but rather water use distortions resulting in less spread and hence less acerage irrigated when compared to the design area to be irrigated. It is more a facility wastage than a water wastage. The end result is that the system puts all it's water on a smaller area and emulates in some ways a compact system.

2. Unreliability of water supplies. Because the supplies in most systems are unreliable, farmers cannot depend on them to make the investments necessary to switch to the crops for which irrigation is highly profitable. This results in their not being willing to construct field channels, level lands etc and appears in the form of lack of farmer demand. Rather than a lack of demand for water, it is a lack of demand for unreliable water and reflects the lack of highly profitable opportunities to use unreliable water supplies. Unreliable supplemental irrigation on crops that do fairly well under dryland conditions appears to the farmers to not be worth the investment and cash outlay.

3. Lack of Marketing. Even where water is reasonably reliable, the largest constraint on it's productive and profitable utilization is the unavailability of marketing channels and infrastructure to connect farms with the demand for higher value products. Behind this infrastructure constraint there are also some demand constraints that are lessening rapidly, but still represent important constraints on the expansion of highly profitable and productive irrigation.

7. Policy Implications for Surface Irrigation Policy of the Review of the Under-Utilization Problem.

The policy implications of the data and literature I have reviewed point to three recommended directions in surface irrigation:

First, and foremost, is the re-orientation of design and administration procedures to achieve water reliability through realistic sizing of canal systems and resorvoir capacties -- a move in engineering from protective to productive

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systems design.

Secondly, a removal of crop restrictions from design and administration policies.

Thirdly, an emphasis on marketing and processing to unlock limits on the switch from low-value to high-value crop patterns.

8. An Examination of the CADA Policy.

The official policy view of the causes of under-utilization start with the lack of construction of field channels, followed in turn by inadequate on-farm water management, lack of participation by farmers in operations and maintainance, and the lack of marketing and processing facilities. The policy for attacking these problems in the official policy view is the Command Area Development organizational approach. Before assessing the potential of the policy conclusions derived above, it is necessary, therefore, to examine the CADA solution.

My analysis and review of the literature leads to the conclusion that the most important thing that irrigation design, construction and administration policy can do to improve utilization and productivity is to improve the reliability and sufficiency of irrigation water delivery. That is what engineers do best and it is the area in which the greatest need appears to exist. Give the farmer access to a reliable water supply and if he has access to a market for high value crops the productivity and equity processes will both "take off" -- in a nutshell that is what the data and literature appear to me to be saying about irrigation policy. The remaining question is how to get the farmer access to markets for high value products? It is in this aspect that we see the data and literature having a common ground with the CADA policy, at least in objectives.

The CADA policy as outlined in the VIth Plan will help to clarify these policy issues:

> "Considerable investment has been made on major, medium and minor irrigation projects in order to create irrigation potential for increased agricultural production. The utilisation of the potential created has lagged behind for various reasons. For this, a comprehensive programme of Com-

mand Area Development (CAD) which will include systematic programme of land consolidation, the scientific land shaping, construction of water courses and field channels to carry water to individual fields, field drains to carry surplus water away from the fields and a system of roads which will enable farmers to carry the produce to the market will be necessary. Besides the other measures, adequate and timely supply of inputs has to be ensured and marketing and other infrastructure facilities created so that the farmers are able to derive optimum benefits from available land and water. ... a great deal of ground still remains to be covered as the task is stupendous."[59]

The above quote properly characterizes the official version of the scope of the CADA approach. It may be fair to group these varied lines of attack into two groups, a group of engineering problems solveable through further construction and land moving works, and a group of "system" or "institutional" problems relating to agricultural and marketing problems for which solutions are less clearly specified.

It appears to us from the literature reviewed that while engineering problems are critical, the need is for reliability-engineering and not field channel or land leveling engineering. With respect to engineering tasks the concern with the CADA approach is with the selection of engineering tasks and not the capacity of the CADA structure to accomplish the tasks. The capacity of the engineering establishment in India to design and construct irrigation works is the strongest aspect of irrigation in India. Irrigation policy in India should take advantage of that strenght by focusing it on the right tasks.

On the engineering side, the CADA has the right capability but the wrong tasks. On the marketing side the CADA has the right task but the wrong capability. The question is not whether improved marketing is critical, the question is how to cause or create improved marketing. It is unlikely that the engineers who predominate in the CADA structure have the capability to design and implement satisfactory marketing efforts which must go beyond simple road and silo construction.

59/ Government of India, VIth Five Year Plan 1980-1985, Planning Commission New Delhi, at page 156.

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Two useful evaluations of the CADA in this light have been reviewd and seem particularly relevant. The first is a general and more conceptual evaluation by Wade in 1976 shortly after the CADA really got underway. Because of the recency of the program Wade admits that:

> "India's Command Area Development Authorities may be vulnerable to these criticisms (the ones he presents) --- though it is still too early to be sure." [60]

Five years later in 1981, Pant re-examined many of the same issues using data on the large Kosi project, which made a good case study since it had severe utilization problems and the basic CADA approach had been experimented with under another name (Area Development Commission) since 1965. These two sources provide a useful examination of the CADA policy in general. In addition to Pant's case study of Kosi, he also reviewed the general experience of the CADA approach, which, by the time of his writing, had field experience on some 71 large projects.

Pant's confirmation of some of Wade's earlier hypotheses makes a review of Wade's concerns more important than they were at the time he made them. Since we are mostly concerned with the capability of the CADA to attack the marketing problem we will focus on reviewing Pant and Wade evaluations in that regard.

One of the threads that runs through Wade's analysis is a concern with the complexity of marketing systems and the difficultly of creating them by public fiat and bulldozer. We think that this problem relates to the inability of public planning to create complex commercial structures. Grains marketing is not the marketing system upon which irrigation productivity depends. Increased irrigation productivity depends on marketing systems which support the switch from low value grains to high value crops. These marketing systems allow irrigation to unlock the employment and income potentials of intensive agriculture. Grains marketing is relatively simple, four single products cover 90% of all cereals sold. Massive silos can store millions of tons of grain in one place, and thousands of railroad cars can

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60/ Wade, Performance

be amassed to transport it.

The delicate, costly and complex marketing and processing systems which are the outlets for high value products involve more than facilities and physical links. They involve commercial-institutional links starting at the farm gate and leading through packing and processing channels, to brokering and wholesaling and finally to millions of retail outlets. While it may be possible to write all of these interactions down on paper so that one has a very comprehensive sounding plan, it is very difficult to create efficient marketing institutions by public fiat the same way a dam gets built. Individually, each commercial link is small, but must be run efficiently by someone in order for the whole to work. Private enterprise is not the only way to make this happen, there are many examples in India, in the U.S. and elsewhere where producer and marketing cooperative structures have worked well. Wade explores this problem as follows:

> "A significant feature of irrigation projects is that engineers dominate in their design and operations. And not only engineers but even the public at large tend to be more excited by big structures and big schemes, the bigger the better. For this reason alone, there is likely to be more enthusiasm and pressure for engineering aspects of irrigation projects than for agriculture and marketing aspects -- which is part of the explanation for low utilisation. The Authorities (CADA's) are founded on the perception that command area development is a complex process ... A consequence of this systems quality is that it invites the drawing up of a comprehensive program of development, which gives the impression of more insight into the problems than is actually available. To some extent, this pseudo-comprehensive technique may be used as bait for financial support from international lending agencies -- for international lending agencies are likely to be very attracted by it. This is all the more so if an organisation is established to co-ordinate and manage the whole irrigation project. International agencies .. are only too easily convinced by new organisational charts which appear to depict in black and white how everything will be coordinated. However helpful integrated command area development agencies may be as a way of securing international financial assistence, they are likely to run into severe difficulties if they actually try to do anything. Too much attention tends to be paid to the benefits, and too little to the costs."[61]

61/ Wade, Irrigation Performance, op.cit.

The idea that something they cannot design or construct or otherwise control is perhaps the second major cause of their poor performance will likely come as hard and unwelcome news to the irrigation engineering establishment. Marketing sits on the juggler vein of irrigation, determining how far it can move in the critical switch from low-value to high-value crops. Reliable water supplies are necessary but they are not sufficient. If there is no one to sell the bananas to, the farmer will not even try to grow them.

Pant's general evaluation of the CADA's based in large part on the in-depth review of the activity of a CADA prototype organization which had been working since 1965 in the large Kosi project. It is useful by way of introduction to Pant's conclusions, that while the Kosi was one of the first large projects to get the comprehensive CADA approach, it was the project among the twelve reviewed by the controller general that had the lowest (18%) utilization rate.

The flavor of the conclusions drawn by Pant in his evaluation of the CADA's performance may be captured in the following quote:

> "Since the inception of the programme in 1974 44 CADA's have been set up, covering 71 irrigation projects all over the country. The performance of CADA's in several states has been rather disappointing ...the major shortcomming of the programme is that it identifies the main deficiencies as the lack of adequate delivery system which should reach up the the farmers' fields, the lack of proper land shaping, and leveling of fields, the absence of drainage where necessary. Thus the technical diagnosis of the problem has led to emphasis on technical solutions -- such as construction of field channels and drains, lining of canals, fixing of regulators, leveling of land etc. overlooking the institutional solutions. "[62]

While marketing and processing are clearly made central functions of the CADA's by national policy, we have seen no evidence to indicate that they have done much of anything in that regard. Pant reviewed what the CADA and its prototype prede

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62/ Niranjan Pant, **Utilization of Canal Water Below Outlet in Kosi Irrigation Project,** Economic & Political Weekly, September 1981.

cessor had done over a 16 year period in the Kosi project and not one word was said about marketing. He and Wade both argue that the CADA's will be engineer operated and dominated and continue to focus on construction solutions. If Kosi is to be used as an example, it would appear to confirm Wade's concerns.

9. Summary of Policy Implications as Seen in a Case Study of Sangli District in Maharashtra: Reliable Water Linked with Processing/ Marketing Infrastructure

The potential of the inherent capabilities which exist in even very under-developed areas in India may be under-estimated in the CADA approach. One has the feeling that official policy assumes the government must do almost everything to make the irrigation miracle of intensive agriculture happen. Inputs must be provided, credit must be mobilized, farmers must be trained and turned around from their backward ways, etc. etc. All of these elements are necessary to the miracle but there is no reason to think that they must be created in a coordinated, and publicly orchestrated way.

The literature and data I have reviewed point to two factors as the leading or key elements. When these two elements are present the appear to unlock indigenous capacities to solve the rest. These two factors are reliable water and marketing/processing institutions and infrastructure. When these two come together they appear to be able to lead the rest without a lot of public intervention. In many cases, processing/marketing institutions such as sugarcane and grape cooperatives have been the initial orchestrators of the irrigation miracle. In the case study cited, processing cooperatives organized lift societies which assured reliable delivery of irrigation water to farmers. Though sugarcane is the particular case study cited, the same pattern has been observed in grapes, citrus, and bananas; and in fact, wherever the cash crop switch to high value products has taken place.

The transformation of a backward, subsistence, and grains dependent economy, to a dynamic developing one depends on what Wade called the "switch" to high value crops. This switch transforms a whole region; it causes a commercial transformation. The characterization of this process and its sequence is ably outlined

in a recent study and it provides a fitting conclusion to this paper's discussion of irrigation policy.

> "Till 1958, the district (Sangli) was considered to be agriculturally backward as the agriculture in the district was mainly dependent on rainfall and there was absence of commercial outlook among the farming communities.- Agriculture was moreover of subsistence nature. But since the establishment of cooperative sugar factories at Sangli (1958-59) and Walwa (1969-70), the agriculture in the district has undergone a tremendous change. There was a shift in the cropping patterns mostly from good grain crops to comercial crops like sugar cane. (Other more productive and less water using such as grapes have since become important) As sugarcane, being an irrigated crop fetching considerable net returns to growers, it motivated many of the cultivators to exploit and use the irrigation resource (through the formation of lift cooperative schemes utilising public canal water).-
>
> This needed necessary financial help and supply of inputs as well. The cooperative institutions in the district came forward to meet this need and as a result of this cultivators were able to get required agricultural inputs including credit in sufficient quantities. This accelerated the process of agricultural deveiopment in the district. The efforts towards exploitation of natural resources yielded desirable results. This not only increased capital formation in agriculture but also increased the productivity of all other resources including land, thereby increasing incomes of the masses."[63]

This rather participatory, and relatively spontaneous and un-orchestrated scenario, driven by processing-marketing and farmer controlled reliable water, was called the "promising path" for irrigation in India by the 1962 Maharashtra Commission. The data and literature I have reviewed confirms both their finding and the optimisim which they used in characterizing it as a "promising path".

63/ Mahatma Phule Agricultural University, Deposit Mobilisation on Farms in Sangli District of Maharashtra, Rahuri, 1982

Appendix E

Analysis of Selected Productivity, Equity and Economic Issues for Irrigation in India

APPENDIX E
Irrigation Sector Evaluation and Strategy Review
USAID/India

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PART I

PRODUCTIVITY

A. Basic Concepts & Definitions

1. Definitions & Concepts of "Productivity"

The purpose of this first section is to explore the measurement of productivity of irrigation in India. The first two subsections examine alternative concepts and definitions for "productivity" in the context of irrigation. The third subsection presents estimates of productivity ratios for rainfed vs. irrigated crops and examines differences in overall productivity between different types of irrigation, such as wells, tanks and canals.

While there are many possible definitions of productivity, the general concept which will be used here is the most common definition which suggests that "productivity" is a measurement of the quantum of some desired output per unit of some scarce input. Productivity by this definition is a ratio with a numerator measuring or estimating the amount of output obtained per unit of input. The productivity of irrigation would be a ratio measuring or estimating the increase in some desired output per unit of some scarce input. Rao outlines some of the alternative choices of numerator and denominator in irrigation productivity ratios as follows:

> "The definition of efficiency in irrigation system could be broadly characterised either in terms of hydrogeological (ie water use efficiency or irrigation efficiency) or socio-economic (productivity/growth and social justice) parameters. In a National Seminar at the Administrative Staff College of India on Multi-disciplinary Organisation Structure for Irrigation Projects (October 1981), it was recommended; "In the ultimate analysis irrigation efficiency is to be measured with reference to the primary objective of irrigation, namely, irrigated agriculture which is the end product of a long process.
>
> Thus, the efficiency of the system as a whole can be measured via efficiency of irrigated agricultural production. The latter can be expressed

in terms of output per unit of the scarce factor, which may be land in some cases and water in others."[1]

Rao's productivity and social justice concepts are used as the analytical framework for this document. Using this framework carries the discussion away from water delivery and into examining irrigation in terms of its impacts on irrigated agricultural production. Following the Rao approach to the analysis of irrigation efficiency seems logical enough, but has rarely been done in India due to the dominance of engineers in irrigation matters. Engineers in India tend to see irrigation systems in "water" terms rather than in "crop" terms. Wade characterizes this water myopia as follows:

> "A ... significant feature of irrigation projects is that engineers dominate in their design and operation... Today one of its consequences is that irrigation engineers tend to view the output of a canal system as water, not the additional crops which that water should allow." [2]

This document will, therefore, concentrate on irrigated crops rather than irrigation per se. Rao's quote further sets the conceptual framework for this documment by suggesting the measurement technique which should be used to quantify productivity for irrigation systems. Rao suggests that productivity:

> "... can be expressed in terms of output per unit of the scarce factor, which may be land in some cases and water in others."[3]

Rao's proposed measurement for the productivity of irrigation is a conceptually very simple ratio with crop output as the numerator, and one unit of either land or water as the denominator.

1/ P. K. Rao, in Niranjan Pant Ed, Productivity and Equity in Irrigation Systems, Ashish Publishing, New Delhi, 1984, 276p, at page 5.

2/ Robert Wade, **The Performance of Irrigation Projects,** Economic and Political Review, January 17, 1976.

3/ Rao, op.cit. p. 5

2. Crop Output: The Numerator in the Irrigation Productivity Ratio

a. Value vs. Quantum of Output

If irrigated agriculture were comprised of a single crop, it might be possible to use the physical quantum of production as the numerator. Since many crops are involved, it is necessary to use agricultural prices as a mechanism for adding apples and oranges together in a single measure of output. For the purpose of this document, farm gate producer prices are used to value both home consumed and marketed products.

b. Net vs. Gross Value to Farmers

Two further refinements in the measurement of the numerator are helpful in fine tuning the ratio to represent a more accurate indication of the desired output of irrigation. The first adjustment reduces the gross value of output by the paid out costs which farmers incur in the production process. The objective of this adjustment is to avoid over-estimating the value of production which comes to the farming sector and stays in the rural areas. The idea is to count only that part of the value of production which does not "leak" outside the irrigated area. To accomplish this objective, I have reduced the value of production by subtracting certain selected cost items which are likely to "leak" outside the farming sector.- The most prominent of these are chemical fertilizer, fuels and mechanical costs.

A more difficult issue is raised with reference to animal power and farm yard manure. Since draft animals must be fed even when not productive, they represent a significant "cost" in real terms to the farm family. It is easier from a computational point of view to add in the forage value of crop residues and then subtract a reasonable cost of animal power than it is to treat animal costs as a part of the farm value of production.

The resulting measure of farm value of production which is used in this document represents a rough estimate of the part of production value which remains in the hands of farmers and farm laborers.

c. Direct vs. Indirect Output

Irrigated agriculture not only benefits farmers and farm laborers, but creates additional value added in marketing and processing of the agricultural products it generates. In order to provide useful productivity estimates these forward linkages need to be added. Ideally, one would use a formal input/output model to estimate these indirect impacts as has been done in other more extensive studies.[4] Formal input/output modeling would include estimates of all economic forward and backward linkage effects but is unfortunately beyond the reach of this particular document. As a second best alternative I have included estimates of the first and second forward linkage impacts, which roughly correspond to wholesale marketing and first stage processing. In a formal input/output model, almost all impacts are covered when five to six forward and backward linkage "rounds" are included. Including the first and second forward "rounds" probably captures about three fourths of the indirect impacts. In the tables which follow direct on-farm and indirect off-farm impacts have been added together.

3. Scarce Resources: The Denominator in Irrigation Productivity Ratios

It is worth repeating in this context Rao's previously quoted suggestion that the appropriate denominator for irrigation productivity ratios is as follows:

> "(Productivity) can be expressed in terms of output per unit of the scarce factor, which may be land in some cases and water in others."[5]

The idea of productivity is that it measures the amount of some desired output gained per unit of some scarce resource. It is important to have a correct scarce resource in the denominator, the two most appropriate for irrigation productivity measurement are land and water.

4/ see S. Daines, et al, Input/Output Matrices for Employment and Income Distribution Analysis (76 Sectors), Sector Analysis Division, Agency for International Development, Washington D.C. 1972, 120 p.

5/ Rao, op.cit. p. 5

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a. Capital and Energy Productivity of Irrigation

Before refining Rao's suggested denominators, we should examine alternatives. Two other basic resources are obviously scarce in India, capital and energy. Accurate benefit/cost analysis, discussed by the author in a separate document,[6] directly addresses the "capital" productivity of irrigation projects and need not be repeated here.

There is some evidence that another type of "capital" is very scarce and constrains the productivity of irrigation systems. The type of capital referred to, is farmer production credit. It may be that the scarcity of production credit to farmers prevents full and efficient utilization of irrigation water and irrigable land. Credit could well constitute an additional denominator for irrigation productivity ratios which would not duplicate the work of benefit cost analysis. In any case, an analysis of "credit" productivity ratios is beyond the reach of the data I have gathered for this paper.

The "energy" productivity of irrigation is a vital issue which needs further analysis in India similar to that undertaken elsewhere,[7] but is beyond the reach of this particular paper.

b. Land and Water Productivity Ratios

The most common traditional unit used as the denominator in productivity measurements for agriculture has been land. Almost all "yield" estimates for agriculture are reported in terms of output per acre or hectare. Recent irrigation commissions have questioned land ratios as the most appropriate measure of productivity on the basis that land is less scarce than water in India. This is complicated because the scarcities of these two resources are interrelated.

6/ S. Daines, **Part I: Benefit Cost Analysis**, In Background on Socio-Economic Analysis of Irrigation in India, SRD Research Group, Logan Utah, 1985, 66p. (Prepared under subcontract to USU-WMSII & CID)

7/ see S. Daines et al, Energy in the Food System: Dominican Republic, Brookhaven National Laboratory, Upton N.Y. and Agency for International Development, Washington D.C., 1980, 213 p.

A partial alternative to separating the analysis into two separate ratios is to conceptually see the scarce resource as "irrigable land" -- land **with** water. While this approach may well produce the best single combined productivity ratio, it lacks precision where water is concerned. Such a combined ratio assumes a more or less fixed water allocation per unit of irrigated land which fails to account for differences in crop water requirements.

Rao argues for using two ratios to account for the fact that in some cases in India irrigable land is the scarcest resource, and, in others, water is the scarcest. For this analysis, I have estimated two productivity ratios: the first is a combined "irrigated land" ratio and, the second, is a pure "water" ratio.

The productivity analysis which follows examines irrigation productivity at two levels: the crop level, and the irrigation system or command level. This analysis commences with estimates of productivity ratios at the "crop" level in Section B. Section C examines irrigation productivity at the irrigation system level in the Deccan Plain based on detailed farm level survey data from Maharashtra.

B. Crop Level Productivity Ratios

1. Land Productivity Ratios at the Crop Level

Table 1 outlines the crop level "land" productivity ratios for irrigated crops based on micro-data in Maharshtra state. The specific crop surveys were principally conducted by Mahatma Phule Agricultural University and are described in a separate document.[8] Rather than estimate an "average" productivity ratio, I have preferred to estimate a range which captures the dominant prevailing agricultural practices. While the micro studies from which the data are drawn are not always comparable, I have attempted to select from these sources, upper and lower

---

8/ S. Daines, A Statistical Profile of Agriculture, Nutrition and Development Trends in India: A Case Study of Maharashtra State, SRD Research Group Inc., Logan Utah 1984, 38 p. (Prepared under subcontract to USU-WMSII & CID). Some of the estimates in these studies have been modified based on the irrigation studies conducted in the Ghod & Girna Commands.

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bounds for ratios which would represent approximately 90% of prevailing farming situations. Eliminated from this range are both the very best growers and the very worst growers of a particular crop.

Table 1
Land Productivity Ratios at the Crop Level
(On & Off Farm Value Product per Hectare Irrigated)

Crop	Rs. 000/Ha. /Crop Cycle Rainfed	Rs. 000/Ha. /Crop Cycle Irrigated	Added 000 Rs./Ha. Irrigated, Adjusted to a 12mo. Cycle
Pulses	0.6-0.9	0.7-2.2	1.5-5.5
Oilseeds	0.5-1.4	0.7-2.7	1.6-6.6
Jowar	0.9-2.2	1.4-3.7	3.3-8.8
Wheat	0.8-2.3	1.8-3.8	4.5-9.2
Rice	0.9-2.2	2.0-4.3	5.1-10.7
Fodder	0.9-1.4	2.2-3.8	5.7-10.0
Cotton	1.6-3.3	3.3-6.5	5.0-9.7
Groundnuts	2.2-4.3	4.8-8.3	7.4-12.3
Spices	2.2-4.6	4.6-7.0	11.6-16.4
Sugarcane		11.0-34.0	7.3-22.5
Onions/Potatoes		8.0-14.0	24.0-42.0
Vegetables		11.5-19.0	34.5-57.0
Fruit		33.0-49.0	33.0-49.0
Grapes & Flowers		62.0-96.0	62.0-96.0

Sources: S. Daines, with the Assistance of J.R. Pawar, A Statistical Profile of Agriculture, Nutrition and Development Trends in India: A Case Study of Maharashtra State, SRD Research Group Inc., Logan Utah, 1984, 38 p. at pages 19 & 20.

The first two columns in Table 1 are computed per crop cycle which creates a distorted picture of true land productivity since there is considerable variation in the number of months a particular crop takes to mature. For example, most vegetable crops take less than four months per crop cycle and three crops may usually be cultivated in a year if irrigation water is available. Sugarcane, on the other

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hand, usually takes 18 months per cycle. Column three in Table 1 adjusts all crops to a 12 month equivalent productivity basis.

Column three also computes the additional product value created by irrigation by subtracting the rainfed yield from the irrigated yield. Since some crops are not usually cultivated without irrigation in the Deccan, the rainfed yield is zero.

Column three is, therefore, an estimate of the net added productivity of land with irrigation in the various crops. Table 1 suggests three different sources of increased productivity which are associated with irrigation. The first of these is the obvious increase in productivity for all crops when rainfed land is given supplemental irrigation. The second source of increased productivity is illustrated by the range in yields which is unlocked by irrigation from non-irrigation factors such as high yielding varieties, fertilization, and other improved practices. The range in yields inside irrigated crops is much larger in column two than for rainfed crops in column 1. The third source of productivity increase is in the cropping pattern allowed by irrigation. It will be noted that the most productive crops are not even possible without irrigation. Irrigation makes it possible to grow more productive crops.

a. Yield Impacts Associated with Irrigation.

There are two types of irrigation associated increases in productivity which relate to yield increases. The first of these is the difference in average yields which are associated with irrigation. This yield influence may be seen in the difference between the averages in column 1 (rainfed) and column 2 (irrigated). It may be seen that for many crops the yield increase would be in the range of a doubling of average yields.

The second yield increase associated with irrigation is the widening of the range of yields in both a relative and absolute sense. In the "relative" sense this is most marked in the first group or grains crops. The "relative" yield range from low to high is less than two-fold for these crops under rainfed conditions, but widens to well over two-fold under irrigation. The shift in magnitude of the "absolute" range in value-product yield is most marked in the non-grains

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crops (cotton, groundnuts and spices). There is roughly a Rs.2,000 range for these crops in rainfed conditions, and a Rs. 3,000 range under irrigation.

The difference in the range (both relative and absolute) which comes with irrigation is likely due to the interrelationships which are known to exist between plant genetic capability, fertilizer, and water. Irrigation unlocks a wider range of possibilities which can either be exploited by improved management, varieties, and fertilizer, or may be unexploited by the lack of the same.

While relative shifts are intersting to agronomists and economists, one should remember that it is the magnitudes of absolute, not relative shifts, that interest the farmer. In this light, it is important to note that irrigation in grains is associated with "absolute" increased yields on the order of 1-3 thousand rupees per hectare per crop cycle. In cotton, groundnuts and spices, the irrigation associated yield increases are on the order of 3-4 thousand rupees per hectare per crop cycle.

The last thirty years of irrigation and agricultural development in India has been dominated by massive public outlays and intensive technical efforts aimed at increasing crop yields in cereals crops. Yields in certain cereals (mostly wheat) responded so well in certain areas and under certain conditions that many thought it would transform agriculture as a whole in India. Recently, there has been widespread concern that the productivity and equity results of these narrow crop yield increases fall far short of expectations.

In the most recent comprehensive analysis of India-wide irrigation (the Jain Commission of 1972) estimates were made of crop yields under irrigated and rainfed conditions in 1967-68. These differences are reported in Table 2 below.

Since these estimates are obtained from random field observations rather than controlled experiments, it is impossible to know how much of the difference in yields were due to irrigation per se, and how much was really attributable to non-irrigation factors such as better seed, fertilizer, or other practices. It may be of some help to examine the impact or apparent effect of non-irrigation options for increasing yields in these same crops. In the Jain report, which is something of a landmark study of irrigation, average yield increases were also

reported based on fertilized and un-fertilized conditions on rainfed land for the same crops. These comparisons are reported below in Table 3.

Table 2
Increasing Crop Yields Through Irrigation
Average Yields under Irrigated & Unirrigated Conditions
(Yield in Kg./Ha. in 1967-68)

Crop	Irrigated	Unirrigated	% Increase
Paddy (Rice)	1,299.	857.	52.0%
Wheat	1,444.	886.	63.0%
Maize	1,627.	1,275.	28.0%
Cotton	281.	111.	153.0%

Source: Irrigation Commission Report, New Delhi, 1972 p. 204

Table 3
Yield Increases through Fertilization and Irrigation
Average Yield Comparisons under Different Practices
(Dry Farms without Fertilizer Yields = 100)

Crops	Dry Farming Fertilizer		Irrigated Farming Fertilizer	
	W/O	With	W/O	With
Rice	100	152	144	177
Wheat	100	125	147	197
Maize	100	131	124	173

Source: Irrigation Commission Report, New Delhi 1972 p. 204

A careful review of these comparisons could lead to different conclusions on attribution depending on how they are read. On one reading it would appear that less than about two-thirds of the total impact of irrigation and fertilizers can be obtained with fertilizers alone under dryland conditions. Another way of using the data would roughly impy the inverse--that about two-thirds of the total impact is irrigation and about one-third is fertilizer. While many would

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suggest that careful interactive experiments under controlled situations have already resolved this issue, the actual performance of these options in the farming population as a whole may provide more useful policy conclusions.

The irrigation option aimed at yield increases is aimed largely at grains since the other crops are seldom grown under dryland conditions. In grains it appears that the physical yield increases due to irrigation (as it is currently practiced on the average in India) are on the order of 30-60%.

Before concluding the introductory discussion of crop yield increasing options it should be noted that physical crop yields are not equivalent to "productivity and equity". It is possible to increase physical yields, for example, 50% through fertilizers and have only a 5% increase in farmer income per hectare when fertilizer costs are discounted. Likewise, it is possible to have a productivity (farmer income per hectare) increase as a result of fertilizer which exceeds the increase in physical yields. This is simply to remind us that crop yields are not really a desired end in and of themselves. Increased physical yields may contribute to desired ends, but this is not necessarily the case. Increased yields may well involve uncompensated higher costs, for example. Considerable computation is required to get from yield changes to final income and welfare conclusions. One of the dangers of using yield increases as final objectives is that one is never certain exactly what the final productivity (income per units) or equity implications are.

When looking at the productivity and equity benefits of irrigation options it is useful to keep costs as well as benefits in full view. The cost of the option of increasing the irrigated area with a view to increasing crop yields is relatively high in India, especially for surface systems. An additional irrigated hectare (actual rather than potential) in India costs from US$3,000-6,000 for surface irrigation and from US$1,000-2,000 for groundwater.

Given the high cost of additional irrigation, an option worth exploring is the productivity and equity benefit of improved water management as contrasted to increasing the area under irrigation. This is the "efficiency" option emphasized in most current planning documents and for which there is growing support among irrigation planners and analysts; it is the national plan's **National Efficiency**

Drive. The productivity and equity estimates contained in this document assist in clarifying the efficiency issue and in suggesting options for public policy.

Before concluding this section on irrigation options for increasing crop yields and, thereby, increasing productivity and equity, it is important to underscore how much attention and budget the "yield increasing" option has received in the last three decades in India. It is fair to say that it has dominated government investment, planning, and technical assistance for the agriculture and irrigation sectors. Almost all irrigation has been constructed with yield increases in mind, and almost all public investment in agriculture outside of irrigation has been aimed at the same narrow objective -- to increase the physical yield per hectare of cereals.

b. Cropping Pattern Differences in Productivity Associated with Irrigation

Keeping in mind the farmer's interest in changing the absolute level of income from each hectare of land, the most important change associated with irrigation is the allowance of cultivation of the really high productivity crops. Without irrigation these crops are not normally cultivated. This difference is hard to conceptualize in yield terms, since without irrigation the yield of these crops is zero, and the relative yield increase associated with irrigation is, therefore, infinity. The absolute increase in income is computable if we subtract the rainfed crops which would probably have been grown without irrigation. Even when these figures are subtracted from the four highest value crops, the absolute increase in income adjusted to an annual basis is Rs. 20-95 thousand per hectare. This dwarfs the productivity increase associated with yield increases. Many non-irrigation constraints (marketing, credit etc.) limit farmer cultivation of these high value crops. It is impossible to assess the impact of irrigation on croping patterns by reviewing crop level data. These factors may only be seen at the irrigation system level in the level analysis which is undertaken in Section C below.

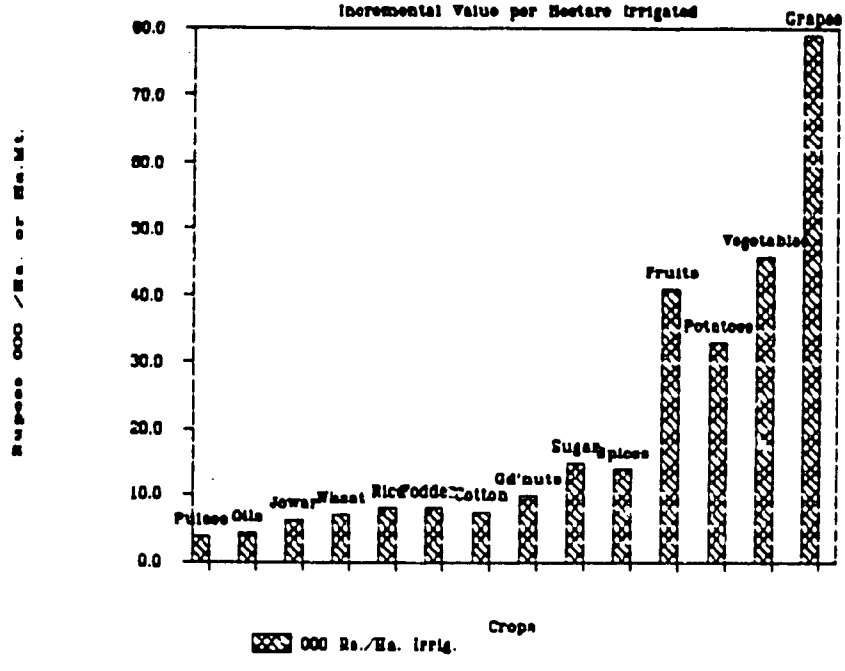
In Table 1, where the crop productivity ratios are presented, it is clear that there are two irrigation associated "ladders" or routes to increased productivity and income. The first of these "ladders" is the "yield ladder" which has about five rungs on it of about one thousand rupees each. Climbing the yield ladder

involves a farmer in mastering the practices associated with high yielding varieties. The yield ladder is the heart of the so called "green revolution". The other ladder associated with irrigation is a cropping pattern ladder in which a farmer diversifies out of lower value crops into higher value crops. The "diversification" ladder has about one hundred rungs on it. The absolute magnitudes of these two ladders may be inferred from Figure 1 where the added value of irrigation is shown for each crop on an annually adjusted basis.

The alternative yield and diversification ladders correspond visually to a farmer climbing from the base line to the top of the crop columns in the left half of Figure 1 (yield ladders), or of stepping from the top of one column to the top of another from the left part of the graph to the right of the graph (diversification ladders).

Figure 1

Land Productivity Ratios for Irrigation



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2. Water Productivity Ratios by Crop

Table 4 presents crop productivity per hectare-meter of irrigation water as contrasted to land as in Table 1. The estimates in Table 4 are based on climatic conditions in the Ahmednagar district of the state of Maharashtra which is taken to be roughly representative of the arid Deccan Plain areas.[9] The individual crop coefficients were obtained from FAO sources.[10] Since climates vary widely in the Deccan Plain, these computations are most useful for comparisons between crops rather than absolute levels of water productivity. Table 2 was calculated in a computer model which also contains data for many other Deccan Plain locations. When climatic data for other locations is used there are no important shifts in the relative position of crops, and few important shifts in the absolute magnitudes of water productivity. One reason for this is that while a smaller quantum of water is required in wetter areas which tends to increase the apparent productivity of a smaller volume of irrigation water, this increase is compensated for by the higher rainfed productivities which must be subtracted to arrive at net incremental benefit. Because of these partially compensating tendencies, the use of the ratios contained in Table 4 may be less limited than otherwise.

With the single important exception of sugarcane, the relative positions and relative magnitudes of differences between crops is the same for water productivity as it was in Table 1 for land productivity. This indicates that, with the exception of sugarcane, the criteria for allocation of scarce land and scarce water would not vary much depending on which is the scarcest.

9/ The basic agroclimatic data for potential evapotranspiration in milimeters (ETo) and mean monthly precipitation were obtained from G. Hargraves, et al, Water Requirements and the Water Balance for India, Utah State University, Logan Utah, 1984, 88 p. at page 50. The methodology used in compiling these water balance tables may be found in G. Hargraves, et al, A Crop Water Evaluation Manual for India, Utah State University, Logan Utah, (Unpublished) 1983, 131 p. plus maps.

10/ The crop coefficient (kc) was obtained from J. Doorenbos & W. Pruitt, Guidelines for Predicting Crop Water Requirements, Food and Agriculture Organization, Rome, 1975, 179 p. at page 60.

c. The Water "Stress Sensitivity" Ladder

Table 2 (with the exception of sugarcane) presents a new kind of productivity ladder, which Wade has correctly sensed is characterized by the relative water stress sensitivity of various crops. He states:

> "Without water, a switch from stress-resistant but low-income crops to stress-sensitive but high-income crops is simply not possible."[11]

Those crops which can be grown without irrigation are in the "stress-resistant" category and roughly include all of the crops in the first section of table 2. There are two exceptions to this categorization. First, and most important, is sugarcane which shows both a low return to water and yet is stress-sensitive. The other exception is spice crops which show a high return to water but are also stress resistant.

Table 4
Total Productivity per Hectare-Meter of Irrigation Water

Crop	Value Product per Ha.Mt. Irrigation Water/Crop Cycle	Incremental Value (Irrig.- Rainfed) per Ha. Mt. Irrig. per 12 mo. period.
	(Rs.000/Ha.Mt.)	(Rs.000/Ha.Mt.)
Fodder Crops	1.8-3.1	4.5-8.0
Sugarcane	7.8-24.2	5.2-15.9
Oilseeds	1.7-6.5	4.7-18.2
Pulses	2.5-7.6	6.9-21.9
Cotton	4.6-9.0	7.6-14.7
Rice	2.9-6.3	7.8-16.5
Jowar	2.9-7.8	8.1-21.1
Wheat	5.2-11.1	14.8-30.0
Groundnuts	11.8-20.4	21.4-36.0
Fruits (Bananas, Citrus etc)	32.0-47.5	32.0-47.5
Spices	16.3-24.9	46.8-70.0
Onions & Potatoes	19.7-34.4	59.0-103.0
Grapes & Flowers	116.6-180.6	116.6-180.6
Vegetables	40.9-67.5	122.6-208.0

Sources: See footnotes 8, 9 & 10.

11/ Robert Wade, **Performance of Irrigation Projects,** Economic and Political Weekly, New Delhi, January 17, 1976.

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Setting aside sugarcane and spices, the balance of the stress-resistant crops are also low-income crops, as Wade suggests. The higher income crops are also stress-sensitive. The incremental returns from adding one Ha.Mt. of irrigation water to the stress-resistant crops is between Rs. 5,000-36,000. One Ha.Mt. of water allocated to the stress-sensitive crops returns Rs. 32,000-208,000. The magnitude of the economic pressure pulling farmers to make what Wade calls the "switch" from stress-resistant to stress-sensitive crops may be seen in Table 4. As a group, the stress-sensitive crops (without sugarcane) return almost ten times as much to water as do the stress-resistant crops. The fact that the returns to land follow essentially the same pattern reinforces this economic pressure.

b. The Sugarcane Case

Sugarcane is a unique crop in that it has high land productivity but low water productivity. It is the most important exception to a general pattern of consistency between iand and water productivity. The indictment of "thirsty" sugarcane by the Dandekar Commission[12] as a wastage of Maharashtra's scarce water seems to be generally supported by the data in this study. However, the apparent conclusion of the Dandekar Commission that water should be preferentially allocated to foodgrains is not, however, supported by the findings in Tables 1 and 4.

c. Wheat and Groundnut Cases

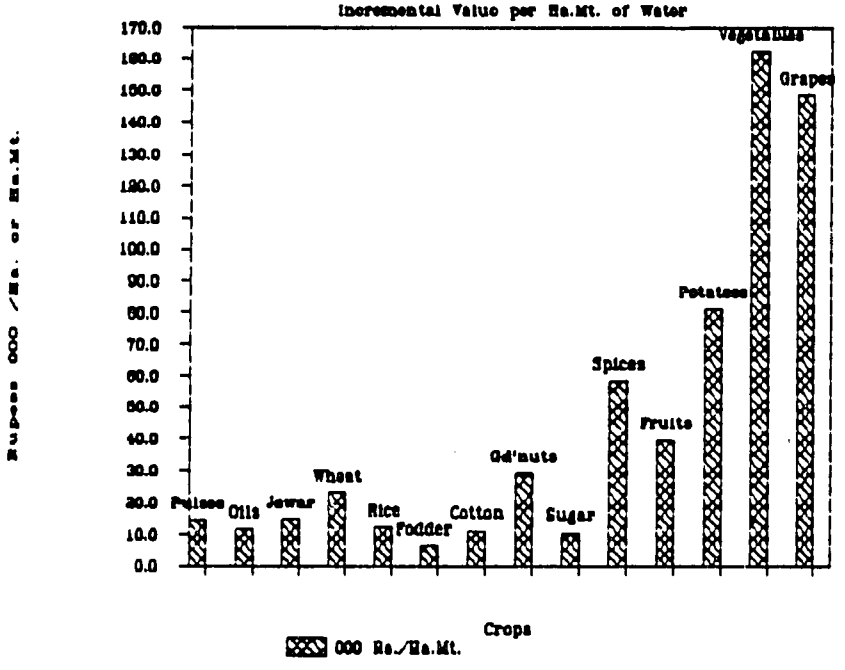
Wheat and groundnuts have the highest returns to water of the stress-resistant group of crops and bear a closer examination. At the upper yield levels these two crops bridge the gap between the two groups. In the Deccan plain less than 10% of all foodgrains were irrigated in 1981, but well over 20% of wheat was irrigated. It would appear that farmers, pulled in part by the high water return of wheat

12/ In 1983 an irrigation commission led by Dandekar released its findings to the Government of Maharashtra. The report was not circulated to the public at large, and I have yet to obtain and review a copy. It is widely known, however, that one of the main conclusions of the commission report is that sugarcane is a poor use of Maharashtra's scarce water. Sugarcane is characterized as a "thirsty" crop which diverts scarce water from nutritionally important foodgrains.

are preferentially allocating this scarce resource to wheat among foodgrains. The recent surge in cultivation of summer groundnuts in Maharashtra may be partially explained by the high water return on this crop.

Figure 2

Water Productivity Ratios by Crop



C. Productivity at the Irrigation System Level

1. Basic Land and Water Productivity Ratios at the System Level

The purpose of this section is to explore how the crop level productivity ratios interact in actual irrigation systems in the Deccan Plain states. At the system level, it is possible to see all of the factors which contribute to productivity interact in a real world situation.

a. The Data

While abundant data are available for the empirical estimation of crop level productivities, there is little data on land and water productivity at the irrigation system level. During the design phase of all irrigation projects, a benefit cost projection is made which contains estimates of the relevant crop mix, costs and productivity ratios. Unfortunately, these projections are not followed by measurements of what actually happens after the projects are constructed. There are very few studies which provide the kind of actual productivity measurements needed for this paper. This paucity of actual data on functioning systems is noted by the Andhra Pradesh Irrigation Commission as follows:

> "No economic analysis has, however, been done of the BC ratio of any project by looking into its final cost and the area actually irrigation and the benefit actually accrued to the farmers from such irrigation and no comparison is made with the earlier assumptions."[13]

The data situation is not quite as bleak as the Commission thought, but there is certianly a severe lack of field data on actual irrigation. I have been able to identify five field studies which provide data of the type needed here for irrigation systems in Deccan plain states. These studies cover irrigation systems in Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. The studies are not internally comparable, however, and it is, therefore, impossible to compute aggregate productivity ratios which include all of these states. This is further complicated by the necessity to include climatic factors in crop water requirements which can only be done for a specific site with its peculiar rainfall, temperature and other characteristics. The computations below are, therefore, based on the system which seemed to be the most representative of Deccan Plain situations. This system is the Ghod system in the Ahmednagar District of Maharashtra.

The field surveys were undertaken in 1976 and included 400 farms randomly

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13/ Government of Andhra Pradesh, Report of the Commission for Irrigation Utilisation, Hyderabad, November 1982, at page 70.

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sampled inside the Irrigable Commanq Area.[14] The computations below were made using data from that survey, however, the computations and the assumptions made are my responsibility and not that of the authors of the survey itself.

b. Productivity Ratios

Table 5 presents the productivity ratios, and cost estimates for the Ghod command. The year selected for the computations is the crop year 1974-75.[15] This

Table 5
Productivity Ratios at the Irrigation System Level
(Ghod System Maharashtra 1974-75)

SYSTEM OUTPUTS	
Ha. Mt. Live Storage	15,900 Ha.Mt.
Ha. Mt. at Field Level*	6,996 Ha.Mt.
Net Area Irrigated	6,806 Ha.
Irrigable Command Area	24,949 Ha.
Total Value of Irrig. Prod.	65,619,000 Rs.
SYSTEM COSTS	
Total System Costs in US$	$39,597,000
System Cost/ Net Ha. Irrigated in US$	$5,818/Ha.
System Cost/Ha.Mt. Farm Level in U$$	$5,660/Ha.Mt.
SYSTEM PRODUCTIVITY	
Unirrigated Land Productivity (in Rs. 1982)	Rs. 1,366/ Rainfed Ha.
Irrigated Land Productivity (in Rs. 1982)	Rs. 9,640/ Irrigated Ha.
Water Productivity (in Rs. 1982)	Rs. 9,378/ Ha. Mt. Water

* At 44% farm application efficiency used in the study cited in footnote 13.
Sources: Computed by S. Daines based on data in Patil et al, op.cit.

14/ R. G. Patil, S.D. Suryawanshi, & P.M. Kapase, An Investigation into the Socio--Economic Conditions in the Ghod Command Area, Department of Agricultural Economics, Mahatma Phule Agricultural University, Rahuri, Maharashtra, 1980, 174 p.

15/ Rainfall for three weather stations in the district which covers the catchment area (Karjat, Shrijonda and Shirur) indicated that 1974 was the highest rainfall year in the period 1971-1975. Ibid p. 158

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crop year followed a better than average rainfall year in the district which allows us to assume that the reservoir will fill and, thus, eliminates statistical confusion which may come from un-utilized live storage capacity. The 1974-75 season was selected as representative of a reasonably mature command in operation. The main works were completed in 1965, and it assumed that the command area development was completed about 1970. This would allow for four seasons of adjustment by farmers to the availabililty of water in the last reaches of the command, and up to ten years in most of the command.

2. Sources of Irrigation Associated Increases in Productivity

a. Overall Increase in Productivity at the System Level

Table 5 indicates that the productivity of an irrigated hectare in the Ghod command was seven times as high as an un-irrigated hectare before the construction of the system. This dramatic increase in productivity, however, does not reflect the total increase in productivity of the irrigable command area as whole. Productivity for the irrigable command area (ICA) increased by only 2.7 times, from Rs. 1,265/ha. before irrigation, to Rs. 3,745/ha. five years after system completion. The reasons for the dramatic difference between the high productivity of hectares actually irrigated, and the productivity of land in the Irrigable Command (ICA) is due simply to the fact that more than two-thirds of the ICA is really "un-irrigable", or ficticious potential. While the system designers claimed it could irrigate 24,949 ha., in reality, it only irrigates about 7,000 ha. This failure should not be seen as a low productivity problem of the water, but rather as a "fiction" created by design optimism. This design fiction has resulted in the so called "under-utilization" of irrigation systems in India, and is discussed by the author in another paper.[16] The productivity result of irrigation in the sample command is substantial. After subtracting the value of rainfed produc-

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16/ S. Daines, Irrigation Policy in India: Historical Trends & Public Policy Issues, SRD Research Group, Logan, Utah, 1985, 73p. (Prepared under subcontract to USU WMSII & CID) See discussion at pages 37-63.

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tion, there is a net productivty increase per irrigated hectare of Rs. 8,274. It should be noted that this is an annual figure and not a crop cycle figure. Since the Ghod command is a major irrigation project with three season irrigation, this figure substantially overestimates the productivity impact of irrigation as a whole. Minor irrigation projects and to a large extent Medium systems as well, are focused predominantly on Rabi season irrigation. If the 12 month figure in Table 5 were converted to a more generally useable crop season basis, the recomputed figures would reveal a productivity increase on the order of Rs.2,000-3,000 instead of Rs. 8,200. This simply illustrates the very large productivity gains which may be had from three season irrigation.

b. Area, Yield, and Diversification Effects of Irrigation.

The purpose of the next three subsections is to divide the total productivity increase associated with irrigation into its three component sources. Irrigation increases the productivity of land by: (1) increasing the crop area by allowing two or three crops to be grown each year instead of only one; (2) by increasing the physical crop yields per hectare cultivated; and (3) by allowing cultivation of crops which cannot be grown under rainfed conditions -- crop diversification.

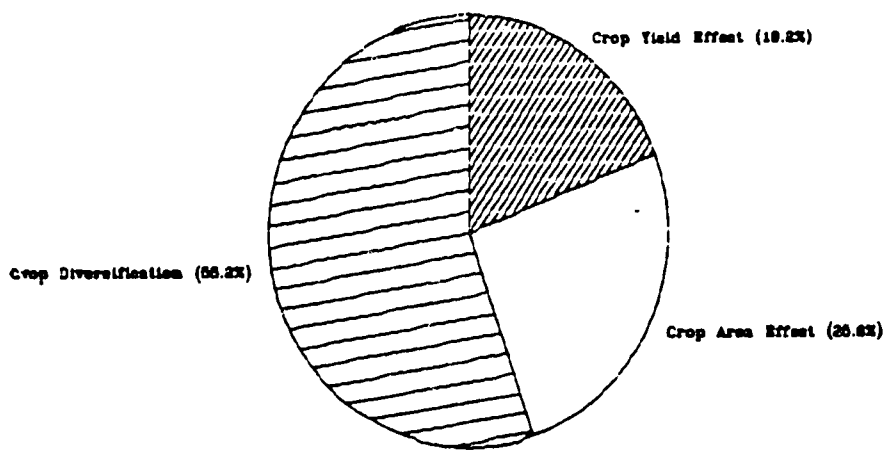
These three sources of irrigation productivity are known as the area effect, the yield effect, and the diversification effect. By utilizing the statistical model whose results are contained in Part III, it is possible to decompose the total irrigation impact on productivity into each of these three proximate sources of that impact. In each case the model compares the irrigated result with what would have been the prevailing use of land under rainfed conditions. Figure 3 outlines these results.

Figure 3 indicates that of the total Rs. 8,200/ha. irrigation associated increase in productivity, 55% is due to crop diversification, 26% due to increased crop area, and 19% due to increased crop yields. The predominant impact of crop diversification supports Wade's conceptualization of irrigation development as a "switch" from stress-resistant but low-income crops to stress-sensitive and high income crops. The Ghod command is a good example of this process, even though actual crop diversification has been minimal in area terms, its impact on total

system productivity has been substantial. If such small diversification shifts can cause such significant increases in system productivity, the potentials of substantial crop diversification should be obvious.

Figure 3

Source of Irrig. Impact on Farm Income
5 Yrs. After Irrigation Development



3. Crop Area Effect

The crop area effect which accounted for 26% of the increased productivity at the irrigation system level is a result of the cropping of the arable land in more than one season. The area effect may be seen in Figure 4 which illustrates the use of the total arable area inside the irrigable command. The top pie chart in Figure 4 illustrates how the arable land in the area which was to become the irrigable command was used before the system was built. Before the system was constructed, 67% of the potential cropped area was uncropped. Since the chart reflects the potential of arable land to be cropped three times each year, the rainfed use of the land indicates a 100% cropping in only one season or one third of its potential crop area.

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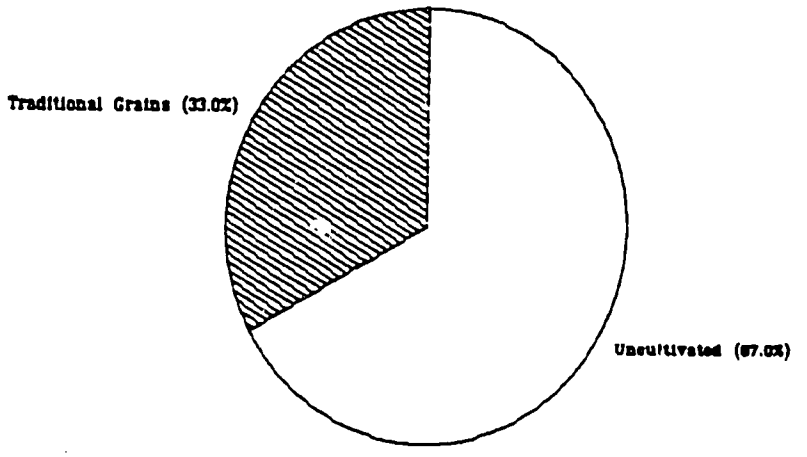
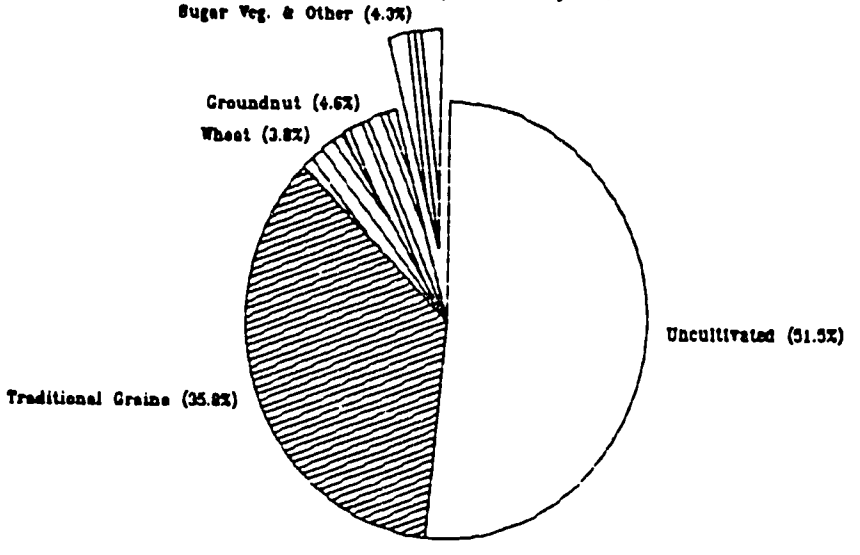
Five years after the system was completed and functioning, the percentage of the gross crop area which was cultivated rose from 33% to 48.5%, and un-utilized crop potential dropped correspondingly from 67% to 51%. These changes in the gross area cropped accounted for 19% of the increased productivity due to irrigation.

Figure 4

Use of the Arable Land
Before Irrigation Development



Use of Gross Arable Land
5 Yrs. After Irrigation Development



4. Crop Yield Effect

The fact that only 19% of the total impact of irrigation on productivity may be accounted for by yield increases is perhaps surprising when compared to the rhetoric of irrigation development in India. The dominant justification of irrigation development in India has been that it would increase crop yields and, therefore, overall agricultural productivity. While irrigation does appear to cause dramatic increases in overall productivity, yield increases appear to be the least important contributing factor associated with higher productivity.

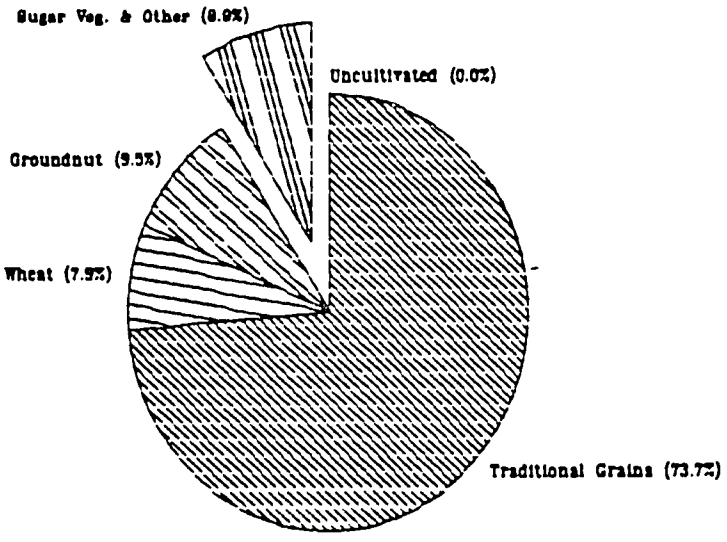
5. Crop Diversification Impact

Crop diversification accounts for 55% of the total increase in productivity associated with irrigation. In each different region the specific crops which are included in the diversification trend will vary. Figure 5 illustrates the degree and type of crop diversification which ocurred in the Ghod command.

Figure 5

Crop Share of Cultivated Land

5 Yrs. After Irrigation Development



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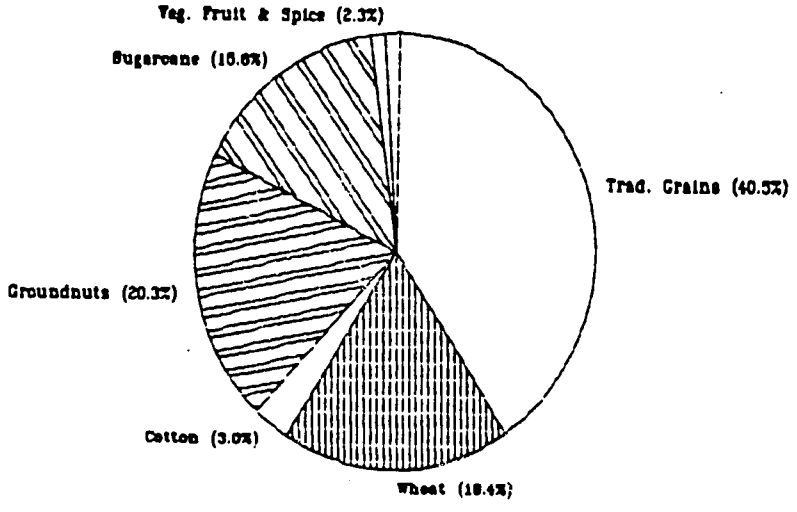
The crop-share pie-chart illustrates the area share in different crops in the Ghod command after irrigation development. It may be seen that only about one fourth of the cultivated area was diversified out of traditional grain crops, and 73.7% of the cultivated land was still used in the same crops. It is important to realize that one of the major reasons for the small percentage area dedicated to diversified crops is the simple fact that irrigation wasn't provided on a reliable basis to all of the irrigable area. While only 27 percent of irrigable area was diversified, 58% of the irrigated land was diversified.

If we eliminate the "ficticious" area which cannot really be irrigated, and look only at the crops grown on land actually irrigated, the result is Figure 6.

Figure 6
Crop Share of Irrigated Area
5 Yrs. After Irrigation Development



The undiversified traditional grains crops occupy only 40% of the area actually irrigated. Almost half of these irrigated grains are grown in the kharif season and may involve only sporadic supplementary watering rather than systematic intensive irrigation. If one subtracts the kharif supplementary irrigation of traditional foodgrains, more than three-fourths of the irrigated crop land is diversified.

From this analysis it would appear that even though markets are an obvious constraint, farmers have found markets which would allow them to diversify at least three-fourths of the irrigated cropland. The appearance of only slight diversification at the system level largely disappears when the ficticious irrigable area and sporadic supplemental watering of kharif crops are both removed. With these two confusing factors out of the equation, it appears that diversification is taking place in almost all reliably irrigated areas, and that these changes are the driving force behind the dramatic increases in productivity associated with irrigation.

6. Intensive vs. Extensive Systems and Productivity

The issue examined in the last three sections has been the degree to which irrigation contributes to increased productivity through area, yield and crop diversification effects. This issue is important since irrigation systems would be designed and managed differently to achieve different mixes of these three effects. For example, if one expects yield increases to be the basic desired objective of an irrigation system, one would attempt to build a system that could reach the largest possible area in the season when crops are normally grown in order to increase the yields of existing crops.

A yields emphasizing strategy would naturally concentrate on kharif irrigation. This strategy is what is known in India as "protective" irrigation since its objective is to "protect" the yields of foodgrains grown in Kharif from the "vagaries of the monsoon". This view has dominated irrigation development in the Deccan, and, in fact, generally in India for the last century. The development and influence of "protective" irrigation policy is explored by the author in another paper and need not be repeated here.[17]

An area policy would concentrate on extending the area cultivated in the season requiring the least cost and for crops requiring the least water. An "area" oriented policy would focus on Rabi irrigation of foodgrains for two reasons. First, less water would be lost to evaporation by focusing on rabi as opposed to

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17/ S. Daines, Irrigation Policy, op.cit.

summer irrigation, thereby allowing for a larger expansion in area cropped. Secondly, the crop focus of an "area" policy would be on foodgrains, since these crops appear at first glance to require less water per unit area than the higher value "cash crops". The fact that these crops have lower water productivity ratios is not obvious to irrgation planners without considerable economic analysis.

Together, the yields strategy with its "protective" bias for kharif foodgrains, and the "area" strategy with its emphasis on Rabi foodgrains have combined to create the kind of surface irrigation system characterized by the Ghod command. The systems which have been designed to favor kharif yield protection and rabi foodgrain areas cultivated are appropriately characterized as "extensive" systems in that the design strategy is to maximize the area reached by a scarce quantitiy of water. The result, seen in the Ghod command where only 27% of the claimed irrigable area is irrigated even in a high rainfall year, has been aptly described by a recent irrigation commission:

> "The net result is that long stretches of main canals, distributaries, and minor canals are built which do not receive any water at all, or if they do, the supply is very inadequate..."[18]

One of the reasons that the canals are dry is that farmers with leverage of one sort or another (head end position, local influence and money) are irrigating diversified crops which the system was not designed to support instead of the kharif and rabi foodgrains the systems were designed to support. A "diversification" oriented system would be designed compact since the high value diversification crops are characteristically either perennials, or short season vegetables and tubers which are most efficiently grown in combination on a year round basis. All of these crops are most efficiently grown with stable year round supplies of water. A compact system with an irrigable command which can actually be irrigated all year would be the ideal system from a diversification point of view.

18/ Andhra Commission, op.cit. at page 69.

To examine the implications of designing irrigation systems for diversification rather than yield and area objectives, Table 6 outlines the results of a simple model which was used to redesign the Ghod command as a compact system and recompute the results in cost, production and productivity terms.

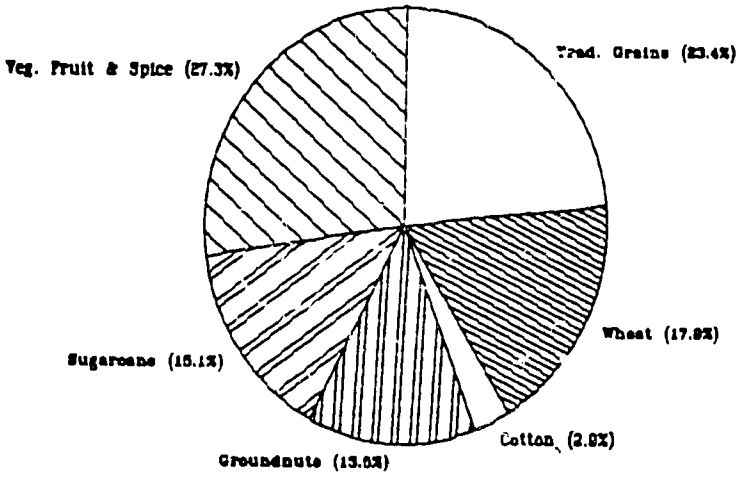
Table 6
Extensive vs. Compact Systems
An Illustrative Model Using Data from the Ghod Command

	Actual System	Compact System
Ha. Mt. Live Storage	15,900 Ha.Mt.	10,000 Ha.Mt.
Ha. Mt. at Field Level	6,996 Ha.Mt.	5,500 Ha.Mt.
Net Area Irrigated	6,806 Ha.	6,806 Ha.
Irrigable Command Area	24,949 Ha.	6,806 Ha.
Total Value of Irrig. Prod	65,619,000 Rs.	113,056,000
SYSTEM COSTS		
Total System Costs (in US$)	$39,597,000	$14,718,000
System Cost/ Net Ha. Irrigated (US$)	$5,818	$2,162
System Cost/Ha.Mt. Farm Level (US$)	$5,660	$2,676
SYSTEM PRODUCTIVITY		
Land Productivity Rs/Ha. "Irrigable"	Rs. 3,745	Rs. 16,611
Rs/Ha. Actual Irrig.	Rs. 9,640	Rs. 16,611
Water Productivity (Rs./Ha.Mt. Storage)	Rs. 4,127	Rs. 11,306
Annual Production Benefits as a Percent of Total System Construction Costs	16.6%	76.8%

The cropping pattern which would result from the compact system may be predicted from farmer diversification behavior with the existing water in already irrigated areas other than the sporadic supplementary irrigation of Kharif foodgrains. This pattern may be seen Figure 7. The pattern still includes almost one fourth of all of the irrigated area dedicated to traditional foodgrains and, including wheat, a total of about 40% of irrigated area in all grains.

The cost savings in the compact system result from eliminating the 63% of Ghod canal which is seldom used, and by reducing the size of the dam by 37%. The cost structure of the system was obtained from World Bank projects.[19]

Figure 7
Crop Share of Irrigated Area
In Alternative Intensive System



The most important comparison in Table 6 where intensive and extensive systems are compared is not the difference in production or productivity, but in the ratio between project construction costs and production benefits. In the Ghod system, annual production benefits are only 16% of costs and, in the compact system annual benefits are 78% of TOTAL construction costs. For the total cost of building the Ghod system in the "extensive" mode, 2.7 compact systems could have been constructed, each with almost double the production benefits of the one "extensive" system.

19/ The cost structure for five major and medium irrigation projects in Maharashtra was obtained from IBRD, Maharashtra Irrigation II Project, Volume III, Supplementary Data, Washington D.C. 1979, 279 p., sources at pages 4, 16, 91, 109 & 118.

PART II

Equity

A. Structure of the Rural Poor.

Equity issues relate to the distribution of income to the poorer, or as they are called in India, the "weaker" sectors. In their most important senses, the words "productivity" and "equity" refer, respectively, to how much is produced per unit of scarce resource, and how well the benefits of productivity are distributed to the weaker sectors. In rural areas these weaker sectors are composed of two groups: (1) small farm families, and (2) landless or marginal rural families. Table 7 outlines the distribution of the rural population into these groups.

Table 7
Structure of the Rural Poor

Distribution of the Rural Population in the Active Labor Force		
Farm workers on owned farms	54.9%	
Farms under 3 Ha.		(32.2%)
Farms over 3 Ha.		(22.7%)
Rural landless laborers	45.1%	

Estimated Percent Composition of the Rural Poor Target Group	
Small Farm Families (less than 3 Ha.)	42 %
Landless and Marginal Farm Families	58 %

Source: Computed by S. Daines based on data in the National Sample Survey, 27th Round (1972-73) as contained in Provisional Results on Employment-Unemployment Survey, October 1977, New Delhi., and on data contained in the Maharashtra Agriculture Census 1977, preliminary results published in 1983, Poona.

The "weaker sectors" in rural areas are composed of approximately 42% small farm families and 58% landless rural laboring families as well as those families with such small plots of land that they are only very marginally involved in farming

and, therefore, are essentially dependent on wage labor or non-farm activities for their sustenance.

In order to understand equity issues as they relate to irrigation options it is important to realize that the largest and poorest segment of the groups referred to above are not the small farm families but rather landless or near landless laboring families. Table 8 outlines some illustrative figures providing a comparison of the relative income levels of these two groups of rural poor.

Table 8
Income Comparisons for Small Farm & Landless Rural Families
Maharshtra

	Average Annual Family Income (Rs. per Year)
Small Farm Families (less than 3 ha.)	5,281
Landless & Marginal Worker Families	2,598

Sources: J. R. Pawar et. al., Employment, Income and Expenditure Pattern of Rural Weaker Sections in Western Maharashtra, MPAU, Rahuri, 1982 and Socio-Eoncomic Survey of the Adopted Village, Nerli, MPAU, 1983.

Two important points must be made about the rural poor as background to understanding irrigation and equity. The first is that small farmers are the smaller half of the rural poor target group and, secondly, that the poorest by a considerable margin are the landless families. This implies that the most urgent equity issue is how irrigation affects employment opportunities (and, therefore, income) of the landless rural families.

B. Equity in the Distribution of Irrigation

An important issue in equity is the fairness of the distribution of water. This is a separate item from equitable impacts on income, but it is a part of the issue. The first point that needs to be made is that small farmers are, by definition, inequitabiy endowed with land or they wouldn't be small. Using gross farm area as an indicator of this land inequity somewhat overestimates the unfairness

of land distribution, because small farms have slightly higher arable proportions than large ones.[20] However, the difference is not large and the distortion is therefore unimportant.

1. Equity of the Distribution of Net Area Irrigated.

Small farmers are, by definition, inequitably endowed with land. The question then becomes whether this land inequity is compounded by an inequitable endowment of irrigation water. It should be noted, however, that the irrigation question must be kept separate from the land question to avoid mixing and confusing the two. At least in Maharashtra it appears that small farmers have more than their proportionate share of irrigation and irrigated area; that is, a larger proportion of their land is irrigated than is irrigated on large farms. That does not mean that irrigation has undone the inequity of land distribution, it simply says that it has partially mitigated it. To say that small farmers' lands do not receive their "fair share" of irrigation does not appear to square with the project data available to me, survey data from the field, or aggregate data from the agricultural censuses.

For Maharashtra, the last agricultural census data (partially reprocessed and computed in the referenced documents) indicates that farmers with under 3 ha. irrigated 11.71 percent of their land, while farmers with from 3-10 ha. irrigated 7.95 percent, and farmers with over 10 ha. irrigated 5.67 percent.[21] In summary, whatever inequity persists in the distribution of water comes from the inequitability of land distribution and not from the inequitable distribution of water.

Perhaps irrigation could be faulted for not having totally undone the inequitable effect of bad land distribution, but from the data I have reviewed it cannot be faulted for deepening that inequity. The actual effect of irrigation on equity

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20/ See, S. Daines, A Statistical Profile of Agriculture, Nutrition and Development Trends in India: A Case Study of Maharashtra State, Vol I. Logan, 1984 38 p. A comparison of the arable area and proportions is in Table 2 at page 5.

21/ Daines, Statistical Profile, op cit p. 4

appears to have been quite the reverse. To an important degree irrigation has reversed the inequitable effect of land distribution. Farms with less than three hectares of land have more than twice as high a proportion of their land irrigated as do large farms with more than ten hectares.

2. Equity of the Distribution of Gross Area Irrigated: Seasonal Inequity

Using "irrigated area" as an indicator, as in the last section, overestimates the fairness of distribution of "irrigation water". It would appear from the data available that small farmers may have captured more than their proportionate share of irrigated area, but they have a somewhat lower proportionate share of area irrigated in more than one season. About 1/12th of the small farm irrigated area is irrigated more than once, while a comparable figure for medium farms is 1/8th and large farms 1/10th.[22] This relative inequity of the seasonal reach of irrigation must seriously bring into question the conclusion reached above that small farmers have captured a larger than proportionate share of irrigation. The additional seasonal reach of the water received by larger farms may look insignificant, unless one adds to the equation the very large additional values of production which may flow from perennial crops which require year round irrigation.

To evaluate the "seasonal" inequity of irrigation as opposed to the "irrigated area" inequity requires the use of more complex computations. Data for such computations are available in raw agricultural census files, and have been reprocessed and computed for this purpose. Using these computations[23] one can derive an index of the cropping intensity of high value crops depending on stretched seasonal irrigation for various farm sizes. These computations are presented in Table 9.

22/ Daines, Statistical Profile, op. cit. page 5

23/ S. Daines, Statistical Profile, op. cit. p. 10

Table 9
Seasonal Inequity in Irrigation
Indices of High Value Cropping Proportions

Farm Size	Ha. in High Value Crops/ Ha. in Low Value Crops
Under 1 Ha.	.469
1-3 Ha.	.562
3-10 Ha.	.590
10+ Ha.	.638
All Farms	.575

3. Equity of the Distribution of Irrigation for High Value Crops.

The last link in assessing the true equity of water distribution is to add the relative values of production of the high value vs. low value crops into the equation. The results of such a computation are shown in Table 10.

Table 10
Seasonal Inequity of Irrigation
Comparisons of High and Low Value Irrigated Crops

	Farmer Income/Ha[24] (000 Rs/Ha.)	
	Lower Tech.	Better Tech.
Low Value Crops Grains, Pulses & Oilseeds	Rs 1.1/Ha	Rs. 2.3/Ha.
High Value Crops Fruits, Veg. Fibers, Sugar Groundnuts, Spices & Tubers	Rs. 6/ha.	Rs. 14/ha.
Differential (high/low)	six fold	seven fold

24/ See, S. Daines, Statistical Profile, Data for this table are drawn from p. 19, rough weights for high value crops are based on figures on p. 9.

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Table 10 implies that whatever inequity is observed in seasonal stretch should be multiplied first by the differential in area in high value seasonally stretched crops, and then multiplied again by the differential in income between high value and low value crops. When these computations are completed the result is rather clear; while small farmers get more than their fair share of irrigated area, that victory is an empty and illusory one. Giving small farmers seasonally limited water, even more than their fair share of it, does not appear to being doing them much good. What is given on one hand in area irrigated, is more than taken away by the real value in seasonally stretched water which they get less than a fair share of. And even though "seasonal" inequity appears small at first, when correctly adjusted for the various multiplier effects it is transformed from a peripheral issue to the central issue.

What has been said of the equity impact of irrigation on the small farmers must be repeated with greater force for the landless since their only entrance into the benefits of irrigation come when on farm labor demands exceed farm-family labor supplies. The probability that this condition will occur is even more directly related to the incidence of high value crops (which are likewise high employment crops)[25] than to small farmer incomes[26].

Small farmer equity is a question not of irrigated vs. non irrigated, but of reliable and seasonally stretched irrigation vs. unreliable and seasonally limited irrigation. Reliability and seasonally stretched irrigation is even more vital to the landless since they only benefit from irrigation when there is enough employment created to exceed the labor capacity of small farm-families. This excess employment comes predominantly from high-value/high-employment crops.

25/ See S. Daines Statistical Profile, op.cit., page 22 for detailed comparison of employment intensities of crops with and without irrigation and at different technology levels.

26/ For a quantification of this point in a case study situation see discussion begining at page 58 of S. Daines Irrigation Policy above cited.

4. Social Justice: Illusions in Water Distribution Equity

Equity is an illusive concept. In the preceding sections we have seen that policies which appear to confer equity on one hand may take it away on the other. There may be large differences between the appearance and the reality of equity. Politicians may give the appearance of irrigation equity by promising irrigation water to poor communities. The systems which are designed to make good on these promises have blueprints showing water reaching the villages and small farmers in them. These promises appear to be comming true when canals and distributaries are constructed carrying the hope of water. The illusion of equity and social justice, however, fades rapidly when the canals and distributaries are dry year after year. What was constructed in the name of "social justice" has created unfulfilled promise in the magnitude of about 66% in the Deccan Plain states. Systems promising water to 100 farmers, in reality delivered it to about 33. Among the 33% served, the lucky small farmers inside this group have captured perhaps a fair share, yet this is small compensation to the multitudes who were promised water and received none.

The discrepancy between promise and performance is highest in those systems designed in the name of social justice when compared with compact or "productive" systems. This contradiction in terms is well described by the Andhra Pradesh Irrigation Commission:

> "The extension of the canal systems for securing social justice ... which ensures ... water to only a fraction of the culturable command area... results in the denial of benefits to many farmers ... thereby creating a large gap in social and economic status..., the very fact that large areas are promised water and expectations of the tail end farmers are raised without ancy chance of their being fulfilled goes against the very core of the objective of social justice..."[27]

Creating real equity for the rural poor in the form of increased income and remunerative employment is quite a different thing from creating the illusion of

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27/ Government of Andhra Pradesh, Report of the Commission for Irrigation Utilisation, Hyderabad, 1982, p. 71

equity through over-extended irrigation systems, which provide unreliable and seasonally restricted irrigation.

5. Solving Hunger: Increasing Food Production vs. Increasing Employment

The dual plights of poverty and hunger of the rural poor in India may be attacked along two rather divergent paths of action and public policy. The first is to increase food production in order to expand the supply of food available. The second approach is to increase remunerative employment possibilities in rural areas in any viable agricultural or rural industry sector, food or non-food.

Equity implies fair access to food. The question is through what mechanism to provide the poor with that access. Irrigation has a role to play in both food production and employment generation for improved rural equity. In recent years there has been considerable discussion among economists about the relative importance of these two paths in solving hunger and poverty in LDC's. Discussion seems to have polarized into two camps--one holding that there is hunger because of a shortage of food, and the other holding that there is hunger because of a shortage of remunerative employment. The "employment shortage" hypothesis appears to be consistent with recent analysis in India.[28] In accordance with this recent Indian research, Poleman generalized the employment shortage position for LDC's in a recent article. Citing the "admirable clarity" with which the President's Commission had "pinpointed the causes of hunger" Poleman stated:

> "(The poor) ... are hungry because they are poor, and they are poor because they do not have jobs that provide a decent income. This statement may sound trite, but it is not. To have said it 20 years ago was to risk derision. When I said it in 1975 in an article in Science, a number of people wrote to say that for them it was an utterly new idea. This is because it flies in the face of the notion --erroneous, but still widely held-- that there is not enough food to go around, and that current world hunger is simply a sign that mankind is losing the race between food production and population growth first visualized nearly 200 years ago by Robert Malthus.

28/ See Amartya Sen, Poverty and Famines: An Essay on Entitlement and Deprivation, Oxford University Press, Delhi, 1981.

"That there is a race no one questions. But it is not the mindless one forseen by Malthus in which food and population rush relentlessly toward some saturation point and ultimate mass starvation. Rather it is a two way race ... in which more and better jobs and the elimination of poverty act as the equilibriating mechanism."[29]

Irrigation plays a key role in both food production and employment generation in rural areas, yet these two roles are not, as will be seen below, entirely complementary. Concentrating on the production of foodgrains does not create much rural employment, whereas cultivating almost any other crop does. Thus, there is an inherent conflict between using irrigation to maximize food production or to maximize rural employment. The conflict between food production and rural employment was clearly sensed by the Maharashtra Irrigation Commission of 1962. Their conclusion appears consistent with the emerging evidence referenced above from Poleman and Sen and with the data examined in this paper. The Commission stated:

"What is really wanted is remunerative agricultural employment of the people; as long as this can be found for them by means of irrigation works, it is a matter of little importance whether they are employed in the cultivation of food crops or of such a crop as cotton or sugarcane." [30]

The sections which follow examine the role of irrigation in generating employment and income for the weaker sectors including landless and small farm families at the crop and irrigation system levels.

29/ Thomas Poleman, **A Reappraisal of the Extent of World Hunger**, Food Policy, November 1981, p. 236. The Commission report cited by Poleman is: Presidential Commission on World Hunger, Overcomming World Hunger: The Challenge Ahead, Washington D.C.-March 1980, p. 49.

30/ Government of Maharashtra, Irrigation Commission Report, Bombay, 1962.

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C. Employment and Small Farm Income at the Crop Level

1. Employment Generated per Hectare Irrigated

Table 11 outlines the on and off farm employment generated by both irrigated and rainfed crops in person days per hectare cultivated for a single crop cycle. The range in the table represents the majority of small and large farm practices in Maharashtra.

Table 11
Employment Generated by Irrigated and Rainfed Crops
Person-days per Hectare per Crop Cycle
(Farm and Off-farm Employment)

Crop	Rainfed Employment Per Ha.	Irrigated Employment Per Ha.
	Person Days/Ha.	Person Days/Ha.
Fodder Crops	12-44	28-55
Rice	32-54	53-80
Jowar	22-50	37-64
Bajra	22-44	27-54
Wheat	22-33	27-39
Pulses	22-33	32-53
Oilseeds	22-33	32-43
Cotton	95-240	125-350
Groundnuts	60-120	100-190
Spices	120-190	240-320
Sugarcane		450-750
Bananas & Other Fruits		360-480
Onions & Potatoes		385-550
Vegetables		300-425
Grapes & Flowers		2,250-3,300

Sources: See sources for Table 1.

Figure 8 illustrates the employment generation relationships by crop in graphic form. In the figure, the vast differences in employment potential of the different crops is obvious. While irrigation does increase the labor required by crops when compared with the same rainfed crop, these small differences are dwarfed

by the very large differences between the low income grain crops as a group and all of the others.

The length of crop cycle varies from the short season 3 month crops to crops like sugarcane which take 18 months to mature. A "crop-cycle" employment indicator such as that presented in Table 11 and Figure 8, therefore, is a distorted view. Figure 9 adjusts crop employment to a common base 12 mo. period.

Figure 8

Total Employment Per Ha./Crop Cycle

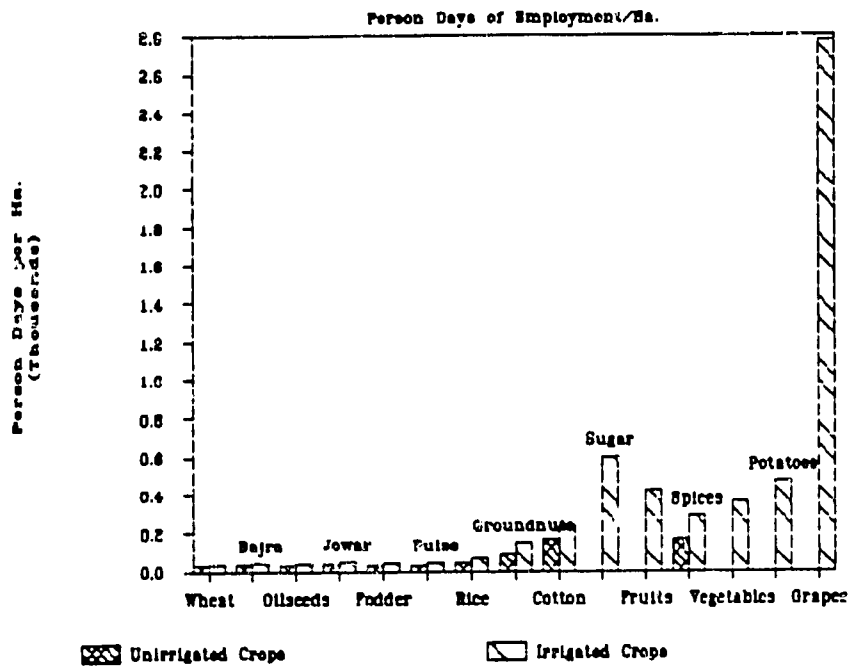
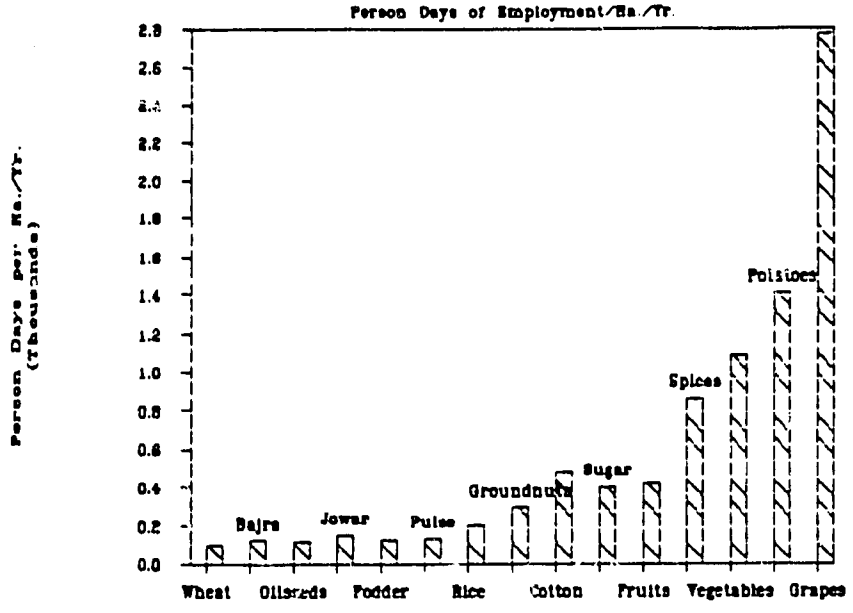


Figure 9

Total Employment Per Ha./12 Mo.



2. Incremental Employment Productivity of Land and Water.

The employment figures given above overestimate the net contribution of irrigation since they fail to account for the employment which would have taken place even without irrigation.

Figures 10 and 11 subtract out the employment of alternative rainfed crops and present the net contribution of irrigation in land and water terms. The low productivity position of sugarcane and bananas which are longer standing and more water demanding is clearer using the "incremental" measures of Figures 10 and 11, than it was in Figures 8 and 9. The very strong employment impacts of spices, potatoes, vegetables, grapes and flowers becomes very clear in Figures 10 and 11.

Figure 10

Incremental Employment per Ha. Irrig.

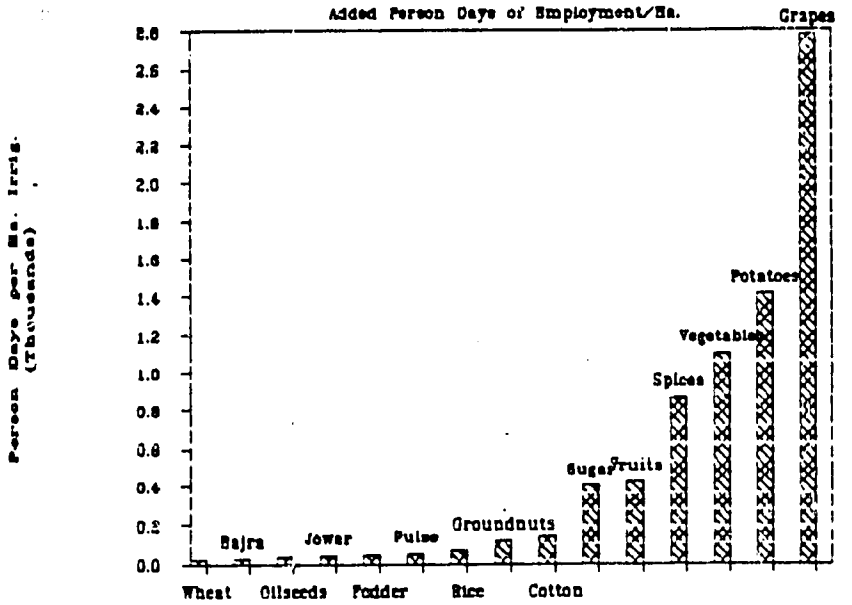
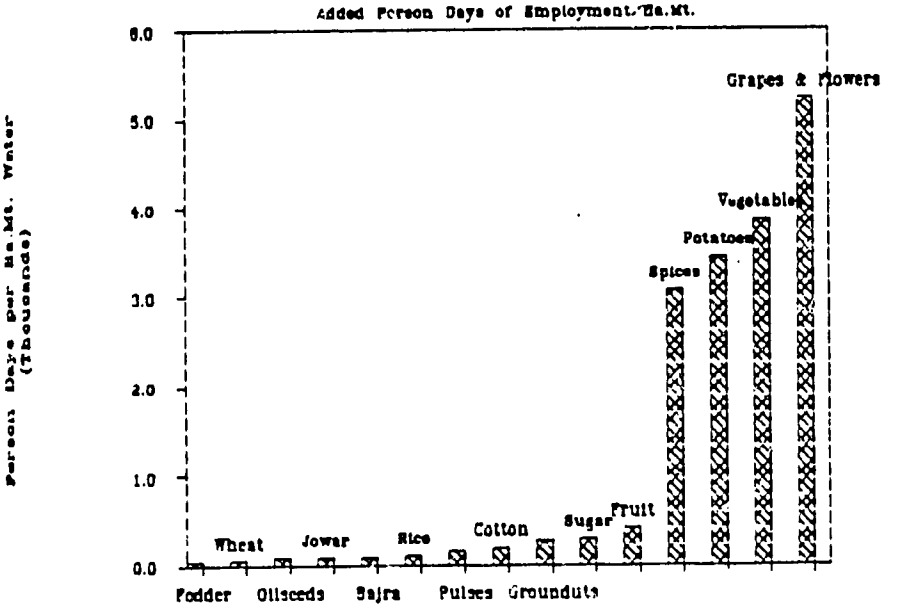


Figure 11

Incremental Employment per Ha.Mt. Water



D. Employment and Small Farm Income at the Irrigation System Level

1. Small Farm Income Patterns in the Ghod Command

Figures 12 and 13 present small farm crop area and crop income shares. Small farms (under 2ha.) dedicated approximately two-thirds of their crop area to irrigated grains, with another one-fourth remaining in rainfed traditional grains and, about 10% in intensive irrigated crops such as sugarcane, vegetables, groundnuts and spices. Figure 13 illustrates the substantial importance of sugarcane as an income source. Even though sugarcane occupies only 4.6% of cropped area in small farms, it contributes one-third of the on and off-farm income generated by small farms. Irrigated and rainfed grains, occupying 90% of cropped area, contributed only 56% to the income generated by small farms.

Figure 12

Small Farm Crop Area
Ha. 1974-75 Based on Ghod Command

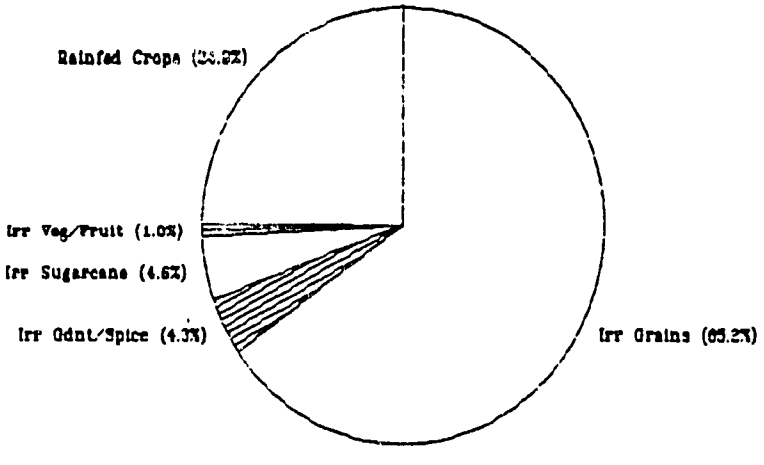
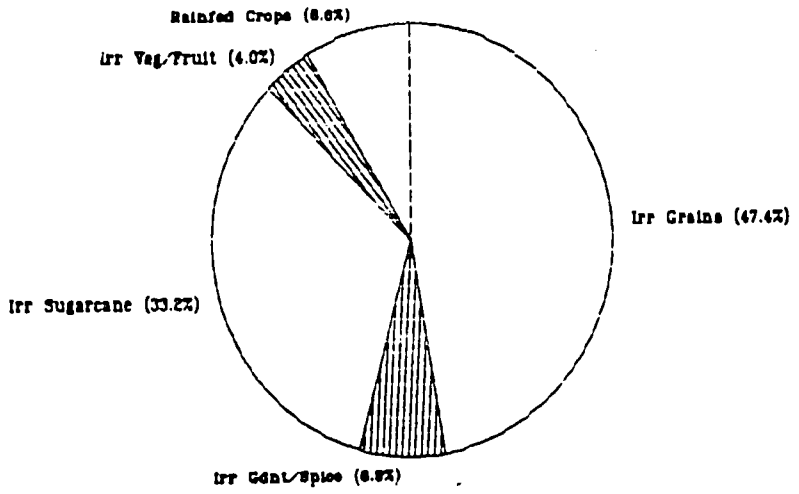


Figure 13
Small Farm Crop Income
Ha. 1974-75 Based on Ghod Command



2. Small Farm Employment and Irrigation

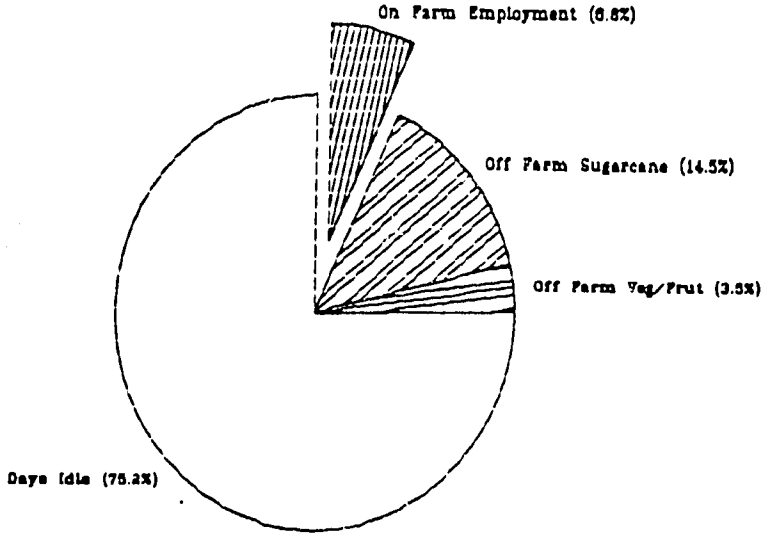
Small farm families, even those who are fortunate to live inside the commands of irrigation projects, are seldom gainfully employed. The most common measures of employment in India fail to capture the very high levels of economic idleness which predominates in rural areas.

Figure 14 outlines the average use of available adult person days in the Ghod command, which is characteristic of the dominant "extensive" type irrigation system. Adults in small farm families, even those with some sugarcane, are actively working in crop production on their own farms for only about 7% of the work year.

The seasonal demands of land preparation, sowing and threshing prevent small farm families from distributing their labor demand over a long period of time. During peak labor demand periods, small farmers even hire outside labor to complement family labor availability. Small farm families join the landless laboring pool during the vast majority of the year, and in the Ghod command, they are employed more than twice as much on neighboring large farms as they are on their own

plots. Sugarcane on other farms is the dominant employment activity of even small farm families. Small farm adults spend about 75% of the available working year in economic idleness, relief works, or informal activities.

Figure 14
Small Farm Family Employment
Days/Wkr/Yr. Extensive System



3. Hypothetical Employment Patterns in Compact Systems

The basic configuration of the compact alternative system outlined above was used to compute the implied employment patterns for small farm families and for landless laborers. The results of this simple model may be seen in Figures 15, 16 and 17. In Figure 15, the implied employment patterns of small farm families in the alternative compact system are displayed. The under-employed or relatively idle period in the compact system has been reduced to 35% compared with 75% in the extensive systems. Most of this added employment was caused by a substantial increase in off-farm employment on large farms in vegetable, fruit and groundnut crops.

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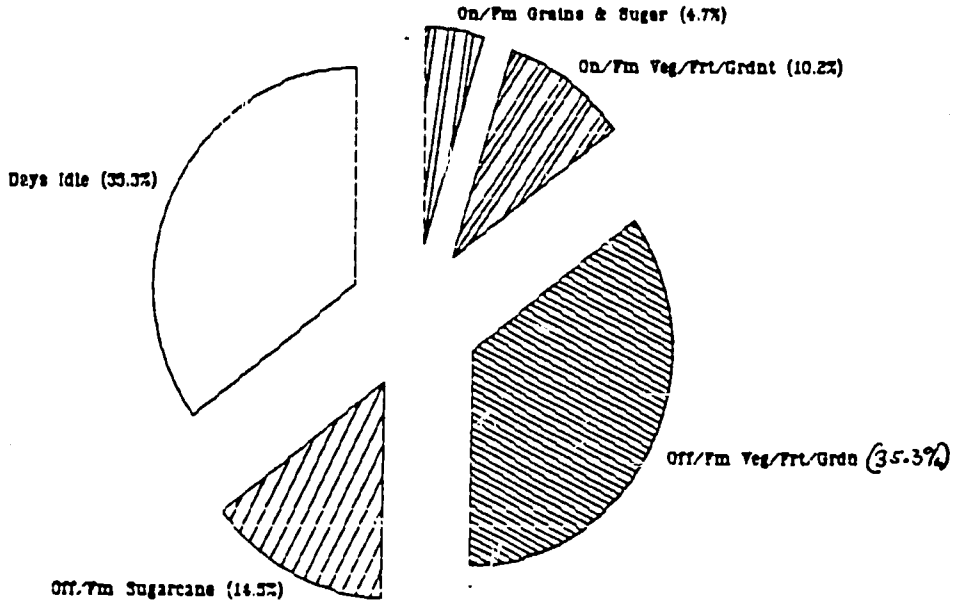
Figure 15
Small Farm Family Employment
Days/Wkr/Yr. Compact System



Employment on the small farms themselves doubled from 7% of the available labor days to 14%. Sugarcane has been held constant. Employment patterns like those seen in Figure 15 closely approximate irrigated situations in the Jalgaon, Sangli and Nasik districts in Maharashtra.

From an equity point of view, one should not fail to notice how the employment of small farm families depends upon the type of crops grown, not so much of their own farms, but that of larger neighboring farms, which provide needed employment.

4. Irrigation and the Employment of the Landless.

The weakest group in the "weaker" sector is the landless group. In irrigated areas there is substantial employment for at least a part of this severely disadvantaged group. Figure 16 outlines employment patterns of landless rural workers in extensive systems such as the Ghod command. Only 4% of the employment of landless workers is provided by small farms. Sugarcane and irrigated large farm grain crops dominate in the employment pattern of landless workers. More than two thirds

of the total person days of available adult labor of landless families is spent in marginal economic activity or idle.

Figure 16

Landless Worker Employment

Days/Wkr/Yr. Extensive System

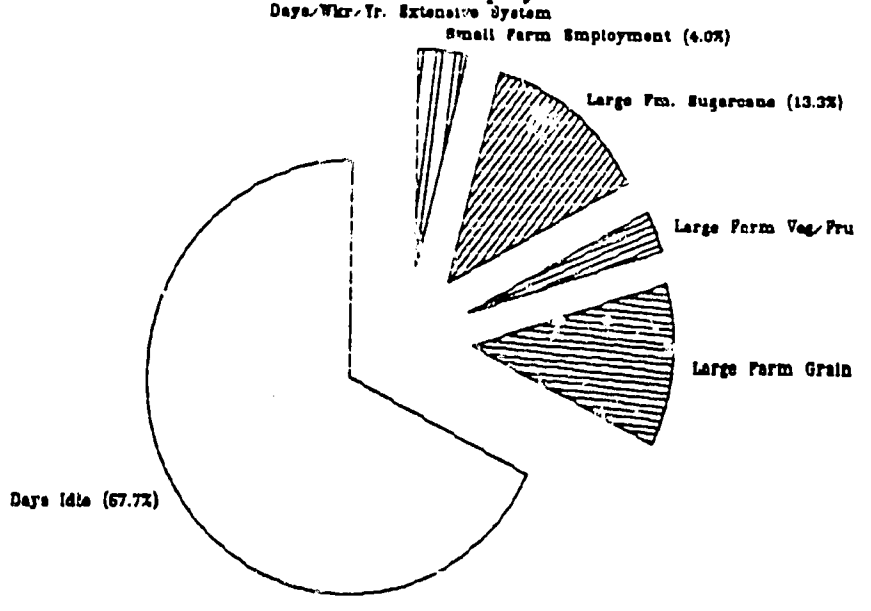
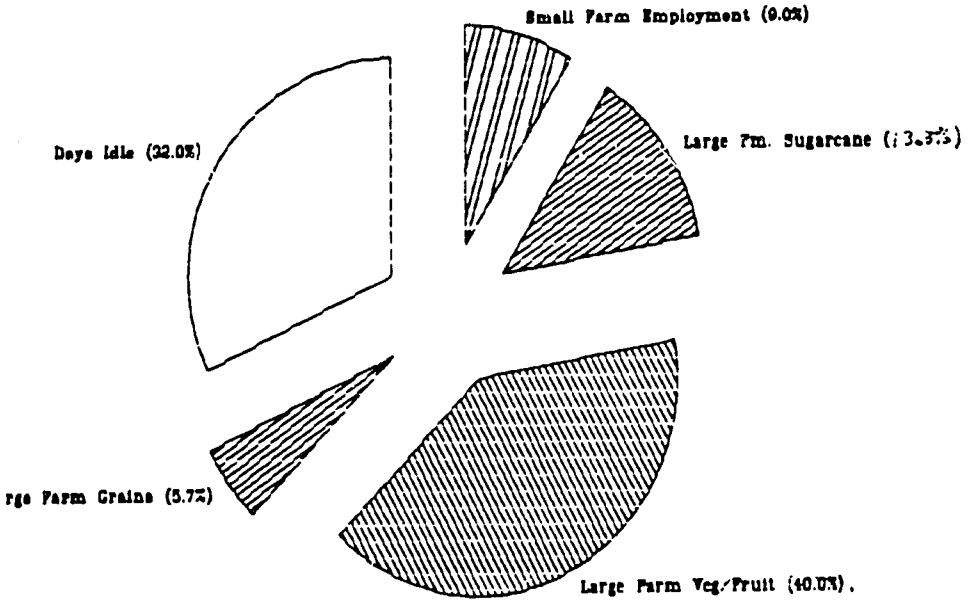


Figure 17 presents projected employment patterns of the landless in a compact system. Small farm employment more than doubles with the increased crop intensity allowed by a compact system, but is still a small part of overall employment. Like the small farm families, landless workers in a compact system would be able to employ almost one third of their available work days in large farm fruit, vegetable, spice, cotton and groundnut crops. The total under-employment or economic idleness would drop for landless workers from about 67% in extensive systems to around 32% in a compact system.

Figure 17
Landless Worker Employment
Days/Wkr/Yr. Compact System



The compact system configured above as an alternative to the extensive type Ghod system, has a cost which is only 37% of the extensive system. In addition to almost doubling the value of production, the much cheaper compact system would also produce more than double the employment for the landless and poor small farm families. In irrigation, equity and productivity seem to lead in the same direction, strongly favoring compact or intensive irrigation systems.

PART III
STATISTICAL MODEL

The statistical results for this document were computed in a Lotus spreadsheet projections model. A summary of the major components of this spreadsheet model are contained in this section. Only summaries of the statistical information contained in the model are reported in the body of the document. The purpose of this section, therefore, is to present the more detailed statistics which form the basis of the projections and conclusions reported in the document itself.

The spreadsheet is a computationally interrelated series of statistical tables, which allow a single number of vector of numbers to be altered and will then provide a recomputation of the balance of the elements. In this way, it was possible to test the various ramifications of redesigning extensive systems in a more intensive mode. The component models in the spreadsheet system are:

EXTENSIVE PRODUCTION MODEL
- Basic Crop Production Coefficients Module
- Crop Water Requirements Module
- Seasonal Cropping Module
- Value of Production Module
- Area, Yield and Diversification Module

COMPACT PRODUCTION MODEL
- Crop Area Module
- Value of Production Module
- Area, Yield, and Diversification Module

PRODUCTIVITY RATIOS MODEL
EXTENSIVE VS. COMPACT COMPARISON MODEL
INCOME DISTRIBUTION MODEL

EMPLOYMENT MODEL
- Crop Level Module
- Crop Water Requirements Module
- Small Farm Share & Cropping Patterns Module
- Farm Employment & Landless Account Module
- Individual Small Farm and Landless Worker Module
- Small Farm Family Summary Account Module

A1: 'EXTENSIVE PRODUCTION MODEL SHEET

	A	B	C	D	E	F	G	H
1	EXTENSIVE PRODUCTION MODEL	Total Value Product per Hectare Cropped						
2	(000 RUPEES 1982)	(High and Low Yield Ranges)						
3	Crop	On-Farm Product		On Farm Product				
4		Low	High	Low	High			
5		Irrigated Crops		Rainfed Crops				
6	Pulses	0.7	2.15	0.6	0.95			
7	Oilseeds	0.7	2.65	0.5	1.35			
8	Bajri & Other Cereals	1.2	3.3	0.8	2.2			
9	Jowar	1.4	3.65	0.9	2.15			
10	Wheat	1.8	3.8	0.9	2.2			
11	Rice	2	4.3	0.9	2.2			
12	Fodder Crops	2.2	3.8	0.9	1.4			
13	Cotton	3.3	6.5	1.6	3.3			
14	Groundnuts	4.8	8.3	2.2	4.3			
15	Spices	4.6	7	2.2	4.6			
16	Onions & Potatoes	8	14					
17	Vegetables	11.5	19					
18	Sugarcane	11	34					
19	Bananas & other Fruits	33	49					
20	Grapes & Flowers	62	96					

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J1: 'EXTENSIVE PRODUCTION MODEL SHEET

	I	J	K	L	M	N	O	P
1		EXTENSIVE PRODUCTION MODEL				kc*ET(o)-AnnPrec=ET(crop)		
2		Crop Water Requirements Module						
3					kc	HA.MT/HA		
4					Crop	ET(crop)		
5					Coeff.	(Ahmednagar)		
6		Pulses			0.225	0.281475	ET(o) from Hargraves	
7		Oilseeds			0.325	0.406575	Water Requirements	
8		Bajri & Other Cereals			0.225	0.281475	and Water Balance	
9		Jowar			0.375	0.469125	For India	
10		Wheat			0.275	0.344025	Ahmednagar	
11		Rice			0.55	0.68805	Also AnnPrec for	
12		Fodder Crops			0.975	1.219725	Ahmednagar	
13		Cotton			0.575	0.719325	kc from	
14		Groundnuts			0.325	0.406575	FAO Crop	
15		Spices			0.225	0.281475	Water Requirements	
16		Onions & Potatoes			0.325	0.406575		
17		Vegetables			0.225	0.281475		
18		Sugarcane			1.125	1.407375		
19		Bananas & other Fruits			0.825	1.032075		
20		Grapes & Flowers			0.425	0.531675		

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R23: 'EXTENSIVE PRODUCTION MODEL SHE

	A	B	C	D	E	F	G	H
23	EXTENSIVE PRODUCTION MODEL				Hectares Cultivated by Crop			
24	Seasonal Cropping Module							
25								
26		Ha.			Rainfed	Seasonal Cropping		
27		Irrig	Rainfed		Before	Irrigated Command		
28			Kharif		Kharif	Kharif	Rabi	Summer
29								
30								
31	Pulses	62.9	42.6		1742.34	38	420	0
32	Sajra Oth.	58.5	51.8		2118.62			
33	Jowar	490.5	506.1		20699.49			
34	Rice	39.7	0.2		8.18			
35					0			
36	Trad. Grains	651.57	600.7		24568.63	2637	3095.3	996
37	Wheat	269.8	0.4		16.36	0	2851.677	0
38	Cotton		0		0	214	0	244
39	Groundnuts	80.7	8.9		364.01	864	0	2286
40	Sugarcane	124.8	0		0	806	806	806
41	Vegetables	4.0	0		0	60	50	246
42		1130.83	610		24949	4581	6802.977	4578

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D49: 'Before SHEE

	A	B	C	D	E	F	G	H
44	EXTENSIVE PRODUCTION MODEL							
45	Value of Production Module							
46								
47								
48		Unirr ICA		Total Value of Production			Rs. 000 1982	
49		Kharif		Before	After----------			
50		Area ha.		Rainfed	Irrigated----------			Unirr
51				Kharif	Kharif	Rabi	Summer	Kharif
52								
53								
54								
55								
56								
57	Trad. Gra	20057		32861	6164	7235	2328	26827
58	Wheat	13		25	0	7985	0	21
59	Cotton	0		0	1049	0	1196	0
60	Groundnut	297		1183	5659	0	14973	966
61	Sugarcane	0		0	4534	4534	4534	0
62	Vegetable	0		0	915	763	3752	0
63	Total	20368	0	34069	18321	20516	26782	27813

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A05: 'EXTENSIVE PRODUCTION MODEL SHEET

AO AP AQ AR AS AT AU AV

5 EXTENSIVE PRODUCTION MODEL
6 Area, Yield and Diversification Module
7

	Tot Post Rs. 000	Tot Ante	Added	Area	Yield	Diversify
Trad. Gra	42554.3	32860.5	9693.7	2965.4	2217.1	4511.2
Wheat	8005.4	25.4	7980.0	3810.1	2848.7	1321.3
Cotton	2244.2	0.0	2244.2	612.6	458.0	1173.6
Groundnut	21598.3	1183.0	20415.3	4123.7	3083.2	13208.4
Sugarcane	13601.3	0.0	13601.3	3234.1	2418.0	7949.2
Vegetable	5429.0	0.0	5429.0	476.2	356.0	4596.9
Total	93432.4	34068.9	59363.5	15222.1	11381.0	32760.5

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AV5: 'EXTENSIVE PRODUCTION MODEL SHEET

AV AW AX AY AZ BA BB BC

5 EXTENSIVE PRODUCTION MODEL
6 Area, Yield & Diversification Module
7

	% Add	% Area	% Yield	% Diversify
Trad. Gra	22.8	30.6	22.9	46.5
Wheat	99.7	47.7	35.7	16.6
Cotton	100.0	27.3	20.4	52.3
Groundnut	94.5	20.2	15.1	64.7
Sugarcane	100.0	23.8	17.8	58.4
Vegetable	100.0	8.8	6.6	84.7
Total	63.5	25.6	19.2	55.2

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L66: 'COMPACT PRODUCTION MODEL SHEE

L M N O P Q R S

COMPACT PRODUCTION MODEL
Crop Area Module

	Hectares cultivated by crop ----------					
	Rainfed	Seasonal Cropping Patterns				
	Before	Irrigated Command			Unirr	ICATOTIRRG
	Kharif	Kharif	Rabi	Summer	Kharif	
Trad. Grains	24568.6	637.0	2095.0	996.0	21042.2	3728.0
wheat	16.4	0.0	2851.7	0.0	14.0	2851.7
Cotton	0.0	214.0	0.0	244.0	0.0	458.0
Groundnuts	364.0	864.0	0.0	1286.0	311.8	2150.0
Sugarcane	0.0	806.0	806.0	806.0	0.0	2418.0
Vegetables	0.0	1060.0	1050.0	2246.0	0.0	4356.0
	24949.0	3581.0	6802.7	5578.0	21368.0	15961.7

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T66: 'COMPACT PRODUCTION MODEL SHEET

T U V W X Y Z AA

COMPACT PRODUCTION MODEL
Value of Production Module

Table 4
Total Value of Production Rs. 000 1982

	Before	After----------			
	Rainfed	Irrigated----------			Unirr
	Kharif	Kharif	Rabi	Summer	Kharif
Trad. Grains	32860.5	1489.0	4897.1	2328.2	28144.0
wheat	25.4	0.0	7984.7	0.0	21.7
Cotton	0.0	1048.6	0.0	1195.6	0.0
Groundnuts	1183.0	5659.2	0.0	8423.3	1013.2
Sugarcane	0.0	4533.8	4533.8	4533.8	0.0
Vegetables	0.0	16165.0	16012.5	34251.5	0.0
	34068.9	28895.5	33428.0	50732.3	29178.9

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13(

AB66: 'COMPACT PRODUCTION MODEL SHEET

AB AC AD AE AF AG AH AI

66 COMPACT PRODUCTION MODEL
67 Area, Yield and Diversification Module
68 Rs. 000
69
70
71
72

	Tot Post	Tot Ante	Added	Area	Yield	Diversity
Trad. Grains	36858.2	32860.5	3997.6	269.6	201.6	3526.4
Wheat	8006.4	25.4	7981.1	3811.0	2849.3	1320.8
Cotton	2244.2	0.0	2244.2	612.6	458.0	1173.6
Groundnuts	15095.7	1183.0	13912.7	2805.7	2097.8	9009.2
Sugarcane	13601.3	0.0	13601.3	3234.1	2418.0	7949.2
Vegetables	66429.0	0.0	66429.0	5826.2	4356.0	56246.9
	142234.8	34068.9	108165.8	16559.2	12380.7	79226.0

MAIN-

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AK66: 'COMPACT PRODUCTION MODEL SHEET

AJ AK AL AM AN AO AP AQ

66 COMPACT PRODUCTION MODEL
67 Area, Yield and Diversification Module
68 Rs. 000
69
70
71
72

	% Add	% Area	% Yield	% Diversity
Trad. Grains	10.8	6.7	5.0	88.2
Wheat	99.7	47.8	35.7	16.5
Cotton	100.0	27.3	20.4	52.3
Groundnuts	92.2	20.2	15.1	64.8
Sugarcane	100.0	23.8	17.8	58.4
Vegetables	100.0	8.8	6.6	84.7
	76.0	15.3	11.4	73.2

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A91: 'PRODUCTIVITY RATIOS MODEL SHEE

	A	B	C	D	E	F	G	H
91	PRODUCTIVITY RATIOS MODEL							
92	Incremental Value Module			Ave. Incremental		Ave. Incremental		
93				Rs. 000/Yr.		Rs.000/Yr.		
94				Per Ha. Irrig.		Per Ha.Mt.		
95								
96								
97	Pulses			3.5		14.4		
98	Oilseeds			4.1		11.4		
99	Jowar			6.1		14.6		
100	Wheat			6.9		22.9		
101	Rice			7.9		12.2		
102	Fodder			7.9		6.2		
103	Cotton			7.4		11.2		
104	Groundnuts			9.9		29.0		
105	Sugarcane			14.9		10.6		
106	Spices			14.0		58.4		
107	Fruits			41.0		39.7		
108	Potatoes			33.0		81.2		
109	Vegetables			45.8		162.5		
110	Grapes			79.0		148.6		

MAIN-

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A111: 'EXTENSIVE VS COMPACT COMPARISON MODEL SHEET

	A	B	C	D	E	F	G	H
111	EXTENSIVE VS COMPACT COMPARISON MODEL							
112	(Includes Rainfed Residuals)							
113								
114								
115								
116			Extensive	Compact	Extensive	Compact		
117			Area	Area	Value	Value		
118								
119			Ha. Cult1	Ha Cult2	Value1	Value2		
120	Trad. Grains		6278.0	3728.0	42554.0	36858.0		
121	Wheat		2851.0	2852.0	8005.0	8006.0		
122	Cotton		458.0	458.0	2244.0	2244.0		
123	Groundnuts		3150.0	2150.0	21598.0	15095.0		
124	Sugarcane		2418.0	2418.0	13601.0	13601.0		
125	Veg & Fruit		356.0	4356.0	5429.0	66429.0		
126	Total Income		15511.0	15962.0	93431.0	142233.0		
127								
128								
129								
130								

MAIN

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A133: 'EMPLOYMENT MODEL SHEET

	A	B	C	D	E	F	G	H
133	EMPLOYMENT MODEL							
134	Crop Level Module							
135	Crop		On Farm Empl.		On Farm Empl.		Off Farm Empl.	
136			Low	High	Low	High	Low	High
137			Irrigated Crops		Rainfed Crops		Irrigated Crops	
138	Rice		50.0	75.0	30.0	50.0	3.0	5.0
139	Jowar		35.0	60.0	20.0	50.0	2.0	4.0
140	Bajri & Other Cere		25.0	50.0	20.0	40.0	2.0	4.0
141	Wheat		25.0	35.0	20.0	30.0	2.0	4.0
142	Pulses		30.0	50.0	20.0	30.0	2.0	3.0
143	Oilseeds		30.0	40.0	20.0	30.0	2.0	3.0
144	Sugarcane		350.0	600.0			100.0	150.0
145	Cotton		100.0	300.0	75.0	200.0	25.0	50.0
146	Groundnuts		75.0	150.0	50.0	100.0	25.0	40.0
147	Fodder Crops		25.0	50.0	10.0	40.0	3.0	5.0
148	Bananas & other Fr		300.0	400.0			60.0	80.0
149	Onions & Potatoes		350.0	500.0			35.0	50.0
150	Vegetables		250.0	350.0			50.0	75.0
151	Spices		200.0	300.0			25.0	50.0
152	Grapes & Flowers		2000.0	3000.0			250.0	300.0

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I133: 'EMPLOYMENT MODEL SHEET

	I	J	K	L	M	N	O	P
133	EMPLOYMENT MODEL							
134	Crop Level Module and Crop Water Requirements Module							
135			Off Farm Empl.			Ha.Mt./Ha		
136			Low	High				
137			Rainfed Crops					
138	Rice		2.0	4.0		0.688		
139	Jowar		2.0	4.0		0.469		
140	Bajri & Other Cere		2.0	4.0		0.281		
141	Wheat		2.0	3.0		0.344		
142	Pulses		2.0	3.0		0.281		
143	Oilseeds		2.0	3.0		0.407		
144	Sugarcane					1.407		
145	Cotton		20.0	40.0		0.719		
146	Groundnuts		10.0	20.0		0.407		
147	Fodder Crops		2.0	4.0		1.220		
148	Bananas & other Fruits					1.032		
149	Onions & Potatoes					0.407		
150	Vegetables					0.281		
151	Spices					0.281		
152	Grapes & Flowers					0.532		

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133

0133: 'EMPLOYMENT MODEL SHEE

O P Q R S T U V

133 EMPLOYMENT MODEL
134 Crop Level & Water Requirements Module
135 Total Days per Ha.
136

137	Rainfed		Irrigated		Ha.Mt.
138 Rice	32.0	54.0	53.0	80.0	96.7
139 Jowar	22.0	54.0	37.0	64.0	107.7
140 Bajri & Other Cere	22.0	44.0	27.0	54.0	144.1
141 Wheat	22.0	33.0	27.0	39.0	95.9
142 Pulses	22.0	33.0	32.0	53.0	151.2
143 Oilseeds	22.0	33.0	32.0	43.0	92.1
144 Sugarcane	0.0	0.0	450.0	750.0	426.4
145 Cotton	95.0	240.0	125.0	350.0	330.3
146 Groundnuts	60.0	120.0	100.0	190.0	356.3
147 Fodder Crops	12.0	44.0	28.0	55.0	34.0
148 Bananas & other Fr	0.0	0.0	360.0	480.0	407.0
149 Onions & Potatoes	0.0	0.0	385.0	550.0	1148.6
150 Vegetables	0.0	0.0	300.0	425.0	1290.0
151 Spices	0.0	0.0	225.0	350.0	1023.1
152 Grapes & Flowers	0.0	0.0	2250.0	3300.0	5216.2

MAIN

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A153: 'EMPLOYMENT MODEL SHEE

A B C D E F G H

153 EMPLOYMENT MODEL
154 Small Farm Share & Cropping Patterns Module
155
156
157
158
159
160

	SmFm2	Alltm	Lgrm	Totsm	Totlg	SmFm% of Area
161 Irr Cereals	120.7	858.5	737.8	1716.5	10496.4	14.1
162 Irr Pulses	7.8	62.9	55.1	110.5	784.3	12.4
163 Irr Groundnut	8.4	78.7	70.3	118.8	1000.1	10.6
164 Irr Cotton	0.0	2.0	2.0	0.0	28.5	0.0
165 Irr Sugarcane	9.1	124.8	115.7	129.5	1645.6	7.3
166 Irr Spices	0.1	2.4	2.2	1.8	31.6	5.5
167 Irr Veg/Fruit	1.9	13.6	11.7	27.0	166.3	14.0
168 Rain Cereals	43.6	558.5	514.9	620.7	7324.7	7.8
169 Rain Pulses	3.5	42.6	39.1	49.6	555.7	8.2
170 Rain Grd'nut	1.9	8.9	7.0	27.0	100.2	21.3
171 Total	196.9	1752.7	1555.8	2801.6	22133.2	101.1

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0179: 'EMPLOYMENT MODEL SHEET

O P Q R S T U V

179 EMPLOYMENT MODEL
180
181
182
183 Farm Employment and Landless account
184

185 SmFmEmp	Lgrmemp	Lndless	Lndless	Totemp	Totsmfm	Lndless
186 perfarm	perfm	emptot	emptot	landless	Family	%Empl
187 days/yr	days/yr	smfm	lgfm		Emply	Lgrm
188						
189 60.8	109.1	49209.4	373716.3	422925.7	55047.8	88.4
190 10.4	27.3	8380.5	93598.8	101979.2	9374.8	91.8
191 45.3	167.8	36662.8	574626.1	611288.9	41012.6	94.0
192 6.6	11.9	5358.4	40651.6	46010.0	5994.1	88.4
193 15.6	50.2	12632.4	171869.0	184501.5	14131.2	93.2
194 139	366	112243	1254462	1366705	125560	456

195
196
197
198

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W176: 'EMPLOYMENT MODEL SHEET

W X Y Z AA AB AC AD

176 EMPLOYMENT MODEL
177 Individual Small Farm and Landless Worker Module
178
179
180
181
182
183
184

185	Lndless	Smfm	SmFm	SmFmTot
186	Emply	FamOn	FamOff	FamEmp
187	PD/WKR	PD/WKR	PerWkr	Perwkr
188				
189 Irr Grains	30.2	8.9	0.0	8.9
190 Irr Gdnt/Spice	7.3	1.5	7.3	8.8
191 Irr Sugarcane	43.6	6.6	43.6	50.2
192 Irr Veg/Fruit	3.3	1.0	3.3	4.3
193 Rainfed Grain	13.2	2.3	0.0	2.3
194 0 0	97	20	54	74

195

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	U	V	W	X	Y	Z	AA	AB
195	EMPLOYMENT MODEL							
196	Small Farm Family Summary account							
197						Days/Worker		
198								
199								
200	Small Farm		On Fm Irr Grains			8.9		
201			On/Fm Veg/Frt/Grdnt			2.5		
202			On/Fm Irr Sugarcane			6.6		
203			On/Fm Rainfed Grains			2.3		
204			Off/Fm Veg/Frt/Grdnt			10.6		
205			Off/Fm Sugarcane			43.6		
206			Days Idle			226.0		
207								
208			On Farm Employment			20.3		
209			Off Farm Sugarcane			43.6		
210			Off Farm Veg/Frut			10.6		
211			Days Idle			226.0		
212								
213								
214								

I J K L M N O P

153 INCOME DISTRIBUTION MODEL
154 Small Farm & Large Farm Module
155
156
157

158		Inc/Ha.	Emp/Ha	SmFmInc	LgFmInc
159					
160					
161	Irr Cereals	2.9	58.0	4978.0	30439.6
162	Irr Pulses	1.8	42.5	199.0	1411.7
163	Irr Groundnut	6.3	145.0	748.4	6300.7
164	Irr Cotton	5.8	237.0	0.0	165.0
165	Irr Sugarcane	28.0	600.0	3624.8	46075.4
166	Irr Spices	6.0	287.0	11.1	189.5
167	Irr Veg/Fruit	16.0	420.0	432.5	2660.9
168	Rain Cereals	1.3	37.0	806.9	9522.1
169	Rain Pulses	0.8	27.5	39.7	444.5
170	Rain Grd'nut	3.3	90.0	89.2	330.5
171	Total	72.2	1944.0	10929.5	97539.9

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P Q R S T U V W

153 EMPLOYMENT MODEL
154 Large and Small Farm Totals Module
155
156
157

158			SmFmEmp	LrFmEmp
159				
160				
161	Irr Cereals		99559.3	608791.8
162	Irr Pulses		4697.9	33332.5
163	Irr Groundnut		17224.4	145015.3
164	Irr Cotton		0.0	6743.2
165	Irr Sugarcane		77675.3	987330.1
166	Irr Spices		530.8	9064.1
167	Irr Veg/Fruit		11352.5	69848.0
168	Rain Cereals		22965.6	271012.8
169	Rain Pulses		1365.4	15281.1
170	Rain Grd'nut		2432.7	9013.8
171	Total	0.0	237804	2155433

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Appendix F

APPENDIX F

RECURRENT COST STUDY OF OPERATION AND MAINTENANCE OF IRRIGATION SYSTEMS IN MAHARASHTRA

by

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March 1985

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March 10, 1985 (Jagannathrao R. Pawar)

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RECURRENT COST STUDY OF OPERATION AND MAINTENANCE OF IRRIGATION SYSTEMS IN MAHARASHTRA

1. INTRODUCTION

The problem of inefficient use of irrigation water is common in almost all the developing countries, and Maharashtra is no exception. There are various reasons, as a result of which a considerable quantum of expensive irrigation water resource remains unused at the system level as well as the same is not used optimally at the farm level. The inefficiencies/drawbacks in operation and maintenance of irrigation systems have been observed to be the important factors among several reasons withholding efficient use of irrigation water, both at the system level and farm level as well. The problems such as excessive use of irrigation water, waterlogging, water losses, inadequate and untimely supply of irrigation water, inequitable distribution of irrigation water among the beneficiaries, improper use of input-mix and crop-mix at the farm level, etc., are directly or indirectly associated with the inefficiencies/drawbacks in the operation and maintenance of irrigation systems.

Topic of the Study

The aspect of efficient operation and maintenance of irrigation systems many times seems to have not been given due attention, as it involves additional burden in the public exchequer. Similarly, from the viewpoint of giving social benefits of irrigation water to a vast majority of the farming community, it is difficult for the Government to raise the level of water rates and thereby collect additional revenue resource to provide for higher level efficiency in operation and maintenance of irrigation systems. However, looking to the importance of efficiency in operation and maintenance of irrigation systems, it is necessary to find out the ways and means for effecting improvements in operation and maintenance services to realize maximum returns from irrigation water.

To explore the above possibility, the present study tries to delineate some of the aspects relating to operation and maintenance of irrigation systems in Maharashtra. In that, an attempt is made in the study firstly understanding the existing arrangements for operation and maintenance of irrigation systems based on Statewide information and secondly, to estimate empirically the costs of operation and maintenance of irrigation systems in relation to revenue receipts from collection of water charges for the sample of irrigation systems.

2. METHODOLOGY

The study was divided into three parts. In the first part, an attempt was made to understand in detail the existing arrangements for operation and maintenance of irrigation systems in the State. The second part related to the aspect of systems characteristics, systems operation and paying for operation and maintenance for the sample irrigation systems selected for the study. An attempt was made in the third part to substantiate the results obtained at the system level by way of gathering relevant farm level information from the sample of beneficiaries in the command.

To accomplish the requirements of the first part, the relevant information on different aspects was obtained from the office records of the Irrigation Department. Personal discussions were held with the senior officials of the Department to understand the procedures and practices of operation and maintenance of irrigation systems.

For the system level study involved in the second part, a sample of major, medium and minor irrigation projects was selected randomly. The number of irrigation projects selected under the individual system categories is given in Table 2.1. The information on different aspects of operation and maintenance of the individual sample systems was obtained with the help of a questionnaire specially designed for the purpose. Further, the information thus obtained was screened critically and finally the sub-sample of five irrigation projects belonging to each of the three system categories was selected for the detailed study. This approach facilitated selection of representative systems by way of eliminating the old and extreme irrigation projects.

Table 2.1: Number of Irrigation Projects in the Sample and Sub-Sample.

System category	Total number of projects	Number of projects in the sample	Number of projects in the subsample
Major	19	16	5
Medium	140	28	5
Minor	1160	41	5
Total	1319	85	15

The farm level study involved in the third part was based on the sample of 192 farms selected at random from 24 sample villages spread over in the command of the six sample irrigation projects (comprising of two major, two medium and two minor irrigation projects). The detailed information on different aspects of farm economy and irrigation water use was obtained by survey method with the help of a questionnaire designed for the purpose.

The data/information thus obtained were compiled and analyzed to work out estimates of different indicators/variables separately for the average irrigation projects and farms.

The results of the entire study are discussed in the following chapters.

3. DEVELOPMENT OF IRRIGATION RESOURCE IN MAHARASHTRA

It is well known that Maharashtra State is relatively less blessed with natural resource endowments; especially with regard to natural precipitation and irrigation water potential. The performance of agriculture, therefore, depends largely on the vagaries of monsoon. In recognition of this fact the State Government has made several efforts during the Plan period for exploitation of irrigation potential by way of completing a large number of irrigation projects and sponsoring programs for establishment of lift irrigation schemes and digging the wells.

Plan Allocations for Development of Irrigation Potential

Since the commencement of the First Five-Year Plan, the State Government has provided separate budget allocations for undertaking irrigation works in different parts of the State. Table 3.1 provides Planwise details of budget allocations for irrigation works in Maharashtra.

Table 3.1: Planwise Budget Allocations for Irrigation Works in Maharashtra.

(Rs. in crores)

	Allocations for irrigation works	Total plan allocations	Proportion of total plan allocations on irrigation works (percent)
Pre-independence	16.60	-	-
First Plan (1951-56)	8.11	147.10	5.51
Second Plan (1956-61)	33.94	229.76	14.77
Third Plan (1961-66)	64.99	434.73	14.95
Annual Plan (1966-69)	59.79	385.85	15.50
Fourth Plan (1969-74)	233.07	1006.40	23.16
Fifth Plan (1974-78)	425.51	1877.61	22.66
Rolling Plan (1978-80)	307.73	1511.53	20.36
Sixth Plan (1980-85)	1334.62	6174.74	21.61
Seventh Plan (1985-90)	2130.00	N.A.	-

Source: Documents of the Five-Year Plans of Maharashtra.

On the whole, the State Government has provided almost one-fifth of its total Plan allocations for the development of irrigation potential through undertaking different types of irrigation projects. The budget provided for irrigation works also included the expenses on account of operation and maintenance of existing irrigation systems, old and new as well, in the State.

Irrigation Projects in Maharasthra

Table 3.2 presents information on the number of irrigation projects in Maharashtra.

Maharshtra has succeeded in completion 14 major projects, 125 medium projects, 1160 minor projects and 354 irrigation lifts during the Plan period up to July 1984. The position of exploitation of irrigation potential will improve a lot on completion of the projects which have been sanctioned so far.

Increase in Area Under Irrigation

As a result of completion of different irrigation projects, the area under irrigation has increased during the Plan period. Table 3.3

Table 3.2: Number of Irrigation Projects in Maharashtra.

Particulars	Major projects	Medium projects	Minor projects	Govt. lifts
1. Projects completed during pre-independence period	5	15	N.A.	-
2. Projects completed during Plan period up to July 1984	14	125	1160	354
3. Projects already sanctioned of which work is in progress	45	105	453	-
4. Projects already sanctioned of which work is yet to be started	5	47	461	1
Total	69	292	2074	355

Source: Office Records of Irrigation Dept., Govt. of Maharashtra.

presents the details of gross cropped area and gross irrigated area in the State for the period from 1962-63 to 1979-80.

The proportion of gross irrigated area to gross cropped area has increased from 6.73 percent to 13.18 percent during the period of about 20 years up to 1982.

Planned and Actual Area Irrigated by Irrigation Projects

The post investments in irrigation projects have enabled the State to create additional irrigation potential. However, the entire irrigation potential of these irrigation projects seems to have not been utilized to the fullest extent. The details of the seasonwide irrigation potential and its actual utilization in 1982-83 are given in Table 3.4 separately for the major, medium and minor irrigation projects in the State.

The information presented in Table 3.4 gives a disappointing picture with regard to the use of the irrigation potential created so far by spending huge amounts of money. Almost 65 percent of the irrigation potential remained unused during the year 1982-83. The problem of underutilization was realtively more chronic in the case of the minor irrigation projects as compared to the major and medium irrigation projects. Besides, the utilization of irrigation potential in the kharif and rabi seasons was quite low as compared to the hot weather season.

Table 3.3: Gross Cropped Area and Gross Irrigation Area in Maharashtra.

('000' hectares)

Year	Gross cropped area	Gross irrigated area	Percentage of gross irrigated area to gross cropped area
1962-63	18963	1278	6.73
1966-67	19202	1476	7.68
1971-72	18115	1622	8.95
1976-77	19742	2242	11.35
1981-82*	20386	2686	13.18

*Provisional.

Source: Handbook of Basic Statistics of Maharashta, Bureau of Econ. and Stat., Maharashtra 1964-1983.

Table 3.4: Seasonwide Potential and Actual Area Irrigated by Different Types of Irrigation Projects in Maharashtra During the Year 1982-83.

('000' hectares)

Season	Potential/ actual	Major projects	Medium projects	Minor projects and lifts	Total for irrigation projects
Kharif	Potential	476.90	279.13	235.99	992.06
	Actual	107.33	86.54	57.06	250.93
		22.51	31.00	24.18	25.29
Rabi	Potential	372.06	189.62	281.96	843.64
	Actual	176.25	75.53	53.89	305.67
		47.37	39.83	19.11	36.23
Hot weather	Potential	55.98	9.85	9.81	75.64
	Actual	37.34	9.99	13.52	60.85
		66.90	101.42	137.82	80.45
Perennial	Potential	99.45	34.17	20.17	153.79
	Actual	30.26	45.75	19.11	95.12
		30.43	133.89	94.74	61.85
Total	Potential	1004.39	512.78	547.93	2065.10
	Actual	351.18	217.81	143.59	712.58
		34.96	42.48	26.21	34.51

(Figures in parentheses indicate percentages of actual irrigated area to potential area.)

Source: Office Records of Irrigation Department, Govt. of Maharashtra.

The low water use efficiency could be attributed because of the following reasons.

1. Lack of proper land development, especially construction of field channels with proper flow control structures.

2. Inadequate drainage facilities resulting in waterlogging and evils associated with ill-drained conditions.

3. Heavy percolation losses.

4. High rate of transmission losses due to unlined channels.

5. Poor and irregular maintenance of field channels.

6. Absence of suitable cropping pattern.

7. Inefficiency in operating the irrigation system.

8. Lack of sense of water management practices among the farmers.

Thus, the inefficiency in irrigation water use could be attributed partly to the drawbacks/shortcomings with the operation and maintenance of irrigation systems in the State.

4. ARRANGEMENTS FOR OPERATION AND MAINTENANCE OF IRRIGATION SYSTEMS

The Statewide arrangements for operation and maintenance of irrigation systems are discussed in this chapter.

Agency for Operation and Maintenance

There is no separate agency for operation and maintenance of irrigation projects. However, the Management Wing of the Irrigation Department is involved in the operation and maintenance of all irrigation projects in the State sector. The lift irrigation schemes of the Irrigation Development Corporation of Maharashtra (IDCOM), a government company, are also looked after by the Management Wing of the Irrigation Department on agency basis. The small irrigation projects (having irrigation potential up to 100 hectares) of the Zilla Parishads are looked after by the irrigation staff working under Zilla Parishads for their operation and maintenance.

After an irrigation project is completed and commissioned, it is handed over to the Management Wing of the Irrigation Department for operation of irrigation system and maintenance of dam, canal and distribution system.

Responsibilities of Irrigation Wing

The Management Wing of the Irrigation Department is expected to perform the following functions relating to operation and maintenance of irrigation:

a. Regulation of flood and water storage in the reservoir;

b. Proper estimation of available water in the reservoir and planning its distribution;

c. Calling irrigation water demand applications and sanctioning the same after scrutiny;

d. Maintenance of canal and distribution system;

e. Proper distribution of irrigation water amongst the sanction holders;

f. Preventing unauthorized use of irrigation water;

g. Measurement of crop acreages; and

h. Assessment of recovery of water charges.

The maintenance of irrigation projects includes various activities such as: (a) ordinary and special repairs; (b) extension and improvement to the completed works including drainage schemes to prevent salinity and waterlogging; (c) proper upkeep of the dam, canal and distribution system, including periodical maintenance of steel work, gates, regulators, etc. (d) removal of silt and weeds from canal; and (e) upkeep of the inspection bungalows, buildings and canal chowkies.

Funds for Operation and Maintenance

The expenditures on maintenance and repairs of irrigation projects are met with from the budget provisions made by the State Government as a part of revenue expenditure. The costs on extension and improvements including construction of drainage works are met with from budget provisions made by the State Government as a part of Plan outlay under capital account.

The budget provisions under revenue expenditure for operation and maintenance of irrigation works in Maharashtra are shown in Table 4.1 for the last three years.

Organizational Structure of Operation and Maintenance

Since Maharashtra has adopted the optional system of irrigation with a view to obtain optimum economic returns from better classes of crops

Table 4.1: Yearwise Budget Provisions* Under Revenue Expenditure for Operation and Maintenance of Irrigation in Maharashtra.

Year	Irrigation potential (lakh ha)			Budget provision (Rs. in crores)		
	Major & medium projects	Minor projects	Total	Establish-ment	Works	Total
1981-82	13.16	4.02	17.18	7.28	5.30	12.58
1982-83	14.11	4.18	18.29	8.61	6.98	15.59
1983-84	15.21	4.33	19.54	10.65	9.48	20.13

*These exclude costs for IDCOM lifts which are met with from the funds provided by said company.

Source: Office Records of Irrigation Dept., Govt. of Maharashtra.

grown under irrigated conditions, the responsibility of Irrigation Department does not cease at the outlet but continues until water is supplied to the variety of crops grown in the command at required irrigation intervals and in requred quantities. Owing to this responsibility and small size of holdings of individual cultivators, the management staff requirement is much higher. Recently, the committee under the Chairmanship of D.N. Capoor went into this problem and made certain recommendations for evolving staff norms. Based on these norms, a normal irrigation section headed by a Junior Engineer is provided to look after irrigation water distribution for the concentrated area of 3000 to 4000 hectares of standard rabi irrigation. In case of scattered irrigation of two or more Minor Irrigation Tanks spread over a taluka or two talukas, one section is provided for about 2000 hectares of standard rabi area. For the individual sections, separate staff is provided for operation (i.e., irrigation water distribution, control of unauthorized irrigation use, assessment of irrigation water demand, etc.) and maintenance of irrigation system. Normally, a subdivision has 4-6 such sections and a division has a control over 4-6 subdivisions. The division is headed by the Executive Engineer and subdivision by the Deputy Engineer. In case of the irrigation projects under Command Area Development Authority (CADA), the divisions and subdivisions meant for operation and maintenance work under the Administrator, who is a multidisciplinary authority coordinating the activities of land development as well as operation and maintenance of irrigation system in the command.

Collection and Utilization of Water Charges

The responsibility of collecting water charges from farmers and other beneficiaries is vested with the management staff provided under each of the irrigation sections. The arrears of water charges (i.e, irrigation and non-irrigation revenue) of the water users who do not pay the current water charges within a period of three years even after due persuation by irrigation staff, are recorded by revenue officers as arrears of land revenue by resorting to coercive measures.

The water charges are levied on the area basis for different crops irrigated in any year. In case of the supply of watr for non-irrigation purposes, however the ater charges are leveied on volumetric basis.

The position of actual demand of water charges and recoveries thereof is indicated in Table 4.2 for the last 3 years. The water charges and other revenue from the irrigation projects are credited to the General Revenue Account of the State.

Process of Fixation of Irrigation Water Rates

The water rate has been defined as charge or fee for providing facility of supply of water.

Table 4.2: Actual Demand and Recoveries of Water Charges in Maharashtra.

Year	Current demand excluding past arrears (Rs. in lakhs)	Recovery during the year (Rs. in lakhs)	Recovery percentage
1980-81	1165.30	812.51	69.73
1981-82	1169.40	967.23	82.71

Source: Office Records of Irrigation Dept., Govt. of Maharashtra.

The Maharashtra State Irrigation Commission has prescribed the following principles for fixation of water rates:

a. The total recoveries on account of water rates during the year should not be less than the annual cost incurred by the State for providing the services;

b. The water rate for a crop should be equitable in the sense that it should be related to the ability of the crop to bear it; and

c. Water rate should be so pitched as not to leave any irrigation potential unutilized on account of either the defects in charging rates of the level of particular rates.

At present the water rates for flow irrigation in respect of food and non-cash crops are fixed at roughly 6 percent of the average gross income from these crops. In case of cash crops the rates are fixed at about 12 percent of their average gross income.

The present water rates which are in force with effect from 1 July 1975 are charged on flow irrigation for all irrigation projects alike are indicated in Table 4.3.

The water charges as given in Table 4.3 are uniform throughout the State and they do not differ among the irrigation systems and for the same seasons. There are, however, seasonal differences in the water charges for the individual crops. These differences are mainly on account of duration of the crop over which irrigation is required and quantum of precipitation likely to be received during the season.

Table 4.3: Per Hectare Water Rates Charged for Flow Irrigation from Major, Medium and Minor Irrigation Projects in Maharashtra.

Crop with season	Water rates (Rs./ha)
1. Sugarcane and plantations	750
2. Other perennial crops	500
3. Kharif seasonal crops	50
4. Rabi seasonal crops	75
5. Hot weather seasonal crops	150
6. Seed production crops in kharif season	100
7. Seed production crops in rabi season	150
8. Hot weather cotton (water supply from 1 March)	400
9. Hot weather cotton (water supply from 15 April)	250
10. Hot weather groundnut (water supply from 1 March)	300
11. Hot weather groundnut (water supply from 15 April)	200
12. Pre-seasonal watering	75
13. Post-seasonal water to kharif crops	20
14. Post-seasonal watering to rabi crops	25

(Note: 3/4 rate is to be charged for the annual and perennial crops where water supply is not assured from the irrigation projects.)

Source: Office Records of Irrigation Dept., Govt. of Maharashtra

Type of Water Charges and Pricing Policy

The water charge for a crop is usually a charge per hectare of the area under the crop. Wherever the water is supplied for non-irrigation

use (i.e., for domestic and industrial use), the water charge is per volume of water. Over and above the water rates, Local Fund Cess is charged as per Zilla Parishad Act at the rate of 20 paise per rupee of water rate.

The Crop-Area basis is adopted for irrigation water rates as it is convenient for measurement. Besides, in almost all the irrigation projects the facilities for measuring water quantities on volume basis are absent. The volume basis of water rate is adopted for the water supplied for non-irrigation use as the water measurement devices for the purpose are required in smaller number.

As stated earlier, the irrigation charges collected by the Irrigation Department are remitted to the State Treasury. The basis for water charges has remained the same in the State. The changes in irrigation charges are not made frequently, however, over a period of time charges are made.

Concern of State Government for Water Use

Because of the necessity to increase food and fibre production to meet the needs of expanding population and to improve the status of agriculture which is the vital component of State economy, the State Government has given a very high priority for the development of irrigation since the inception of the first Five Year Plan. Large allocations for this sector were the features of all the Five Year Plans. Table 4.4 presents the information on Planwise budget allocations for irrigation projects in Maharashtra.

Table 4.4: Planwise Budget Allocations for Irrigation Projects in Maharashtra.

Plan period	Allocation for irrigation projects
Pre-independence	16.80
First Plan (1941-56)	8.11
Second Plan (1956-61)	33.94
Third Plan (1961-66)	64.99
Three years	59.79
Annual Plan (1966-69)	
Fourth Plan (1969-74)	233.07
Fifth Plan (1974-78)	425.51
Rolling Plan (1978-80)	307.73
Sixth Plan (1980-85)	1334.62
Seventh Plan (1985-90)	2130.00

At the beginning it was observed that the performance of the new projects was not up to the expectations. A study was, therefore, undertaken during the sixties to evolve strategies to improve the utilization of irrigation potential and to remove bottlenecks in utilizatin of available irrigation potential. One of the major drawbacks which was noticed initially was the lack of infrastructure beyond the outlet. Therefore, construction of watercourse and field channels including ancillary structures thereon was one of the important factors inducing farmers to utilize irrigation water. Keeping this point in view, certain amendments were made to the irrigation laws so that irrigators in the lower region of the outlet could take resort to get the watercourses constructed. However, this was not enough to accomplish the goal of fuller utilization of irrigation potential. The State Government, therefore, undertook the activity of constructing watercourses under the provisions of Bombay Land Improvement Scheme Act-1942 and the costs were recovered from the beneficiaries in yearly installments. From 1980 onwards, the State Government has decided to construct all channels right up to last farm gate at project cost.

Secondly, leveling and bunding of lands in the command area to make them suitable for irrigation was found to be another bottleneck in the realization of potential benefits from irrigation. This activity was, therefore, taken up under the Bombay Land Improvement Scheme Act with the consent of the beneficiaries. The cost on this account is being recovered from the beneficiaries in yearly installments.

The other measures relating to credit supply, seed distribution, etc. were adopted with the help of other departments and Zilla Parishads to enhance production.

Subsequently, it was found that the irrigation distribution system is deficient, water losses are more, irrigation water control facilities are inadequate and canal capacities are not sufficient to meet the peak crop water demands. The Irrigation Department has, therefore, decided to effect improvements in these aspects through remodeling and modernization programs. Moreover, this is going to be the priority sector item for the Seventh Five-Year Plan.

In spite of the above steps, there remained several inefficiencies and deficiencies in the operation and maintenance of irrigation projects in the State. In recognition of these facts, there has been a growing concern these days regarding effecting improvements in the operation system and developing procedures for proper water delivery schedules. The aspects such as water budgeting and estimation of water demands of crops adjusting the release to suit the changes in climate are considered to be much dependent on scientific knowledge relating to crop water demands at various stages of crop growth. The Government is, therefore, making efforts to create a quick feedback information system by way of providing telephone and wireless systems in various parts of the command. Efforts are being made to improve the existing 'shajpali' system on scientific lines. The maintenance norms has also been updated and adequate funds are being provided for proper maintenance of the system.

Government Policy Regarding Collection of Water Charges

At the beginning of the Plan period, the water rates were fixed on ad-hoc basis. However, in accordance with the recommendations made by the Maharashtra State Irrigation System, the policy was changed to relate water rates individual crops to their average gross income such that the Government would be able to recover at least the annual cost on account of providing services.

The Government has adopted the policy of changing water rates after a period of ten years. The current water rates of individual crops as given in Table 4.3 were fixed in 1973-74 and made effective from July 1975 onwards. Owing to this policy, the changes in water rates have not matched with the changes in general price level.

So far as the agency for collection of water rates is concerned, the Government policy was to collect water rates with the help of Revenue staff. This policy was, however, changed from 1976 and the responsibility of collection of water rates from the beneficiaries was vested with the Irrigation Department staff looking after operation and maintenance of irrigation system.

Water User Organizations

The State Government has tried to establish Pani Panchayats (water user organizations) and Canal Advisory Committees. The objectives of such bodies could be seen from the rules for the same as outlined in Annex I.

The Canal Advisory Committees are exisiting on almost all the canals. However, because of certain disputes among the irrigators, Pani Panchayats have not become popular. In recent days, with the introduction of rigid Shejpali or modified Warabundi system, the outlet committees are coming into prominance for the purpose of distribution of irrigation water.

So far as the use of irrigation water on volumetric basis is concerned, there is only one cooperative society of farmers, viz., Sadwad Mali Pani Puravatha Mandali, which is taking water from Niri Right Bank Canal and distributing it among its members. The other uses of irrigation water on volumetric basis are the large farms of Maharashtra State Farming Corporation Ltd.

With a view to maximize use of canal water, to reduce complaints about irrigation water distribution. to decentralize powers and to train the irrigators in cooperative living, the Maharashtra State Irrigation Commission in its report of 1962 has recommended that the work of distribuiton of canal water should be entrusted to the cooperative societies of irrigators. The State Government accepted the

recommendation of the Commission in principle and initially proposed to hand over the work of distributon of canal water to the cooperative sugar factories where 75 percent of the irrigators agree to entrust the responsibility to the cooperative sugar factories. However, this could not become a reality as there was no response to this proposal. Only two cooperative sugar factories on the Pravara canals in Ahmednagar district accepted this responsibility, but gave up the same to the Government after the experience of one year. Thereafter, none of the cooperative sugar factories came forward to take up this work.

Subsequently, the State Government has made a provision under Section 72 of the Maharashtra Irrigation Act 1976 for handing over the responsibilty of management and distribution of water to water committees in case of the canal which is likely to irrigate lands not exceeding200 hectares. This provision has been made to ensure more economical distribution of irrigation water.

Though there are no water user organizations in a large number, a provision has been made to supply irrigation water to such organizations at the concessional rate and they are expected to charge the water rates from the cooperators not exceeding the rates charged for the general irrigators who are not members of the organizations.

Legal Sanctions for Recovery of Arrears of Water Charges

As per the Maharashtra Irrigation Act, the Irrigation Department has prescribed the following dates for payment of the current water charges by the irrigators.

a.	Kharif season	-	31 May of following year
b.	Rabi season	-	31 August of following year
c.	Hot weather season	-	31 January of following year

If the water charges are not paid on the prescribed dates, an extra penalty charge at the rate of 10 percent on the amount due is to be levied. Similarly, if an applicant is in arrears of payment of water charges which became due before the date of application for supply of water, the application is either rejected or sanction is given provisionally subject to the condition that such arrears are paid before a specified date prior to commencement of irrigation supply. The enforcement of this provision, as per canal rules, is dependent on the general rainfall conditions in the commands of the irrigation projects and consequent replenishment in the storages.

In case if an irrigator fails to effect payment of arrears as outlined above, the arrears of water rates are recovered through coercive measures by resorting to the provisions made under the Maharashtra Land Revenue Code.

Government Policy Towards Input and Crop Pricing

The general policy of the Government is to supply various forms of inputs to the farmers at reasonable prices and to give them incentives to produce more by way of assuring minimum remunerative prices for the crop output. However, the implementation of this policy is limited to specific forms of inputs and to certain crops. For example, the Government has a control over the prices of fertilizers, electricity, seeds of improved and high yielding varieties of the crops such as foodgrains, oilseeds and cotton, and canal water. The prices of these inputs are declared well in advance and, many a times, they are subsidized. The policy of charging differential interest rates on the loans borrowed by farmers for prodution purposes is in operation. Such types of price policy measures are, however, totally absent in case of plant protection chemicals and fixed capital inputs.

The assure minimum remunerative prices for crop output to the farmers, the State Government has constituted the Agricultural Prices Committee which is supposed to make recommendations relating to minimum prices of output based on cost of production of different crops. The crops covered under this policy are major foodgrain crops, cotton, onion, tobacco and sugarcane. The minimum statutory prices are declared well in advance after obtaining consent of the Central Government. The farmers are free to sell their produce at higher price in the market. In case the market prices fall below the statutory prices declared, they are able to sell their produce to the procurement centres/organizations operated by the Government. The monopoly cotton procurement scheme operated by the State since the last decade prohibits the private traders effecting direct purchases of cotton from the producers.

To make recommendations of minimum prices, the State Government makes use of the farm level cost of production data of various crops collected with the help of a separate machinery operating at the Agricultural Universities in the State.

Financing of Operation and Maintenance of Irrigation Projects

As stated earlier, the financing of operation and maintenance of irrigation projects is done through the budget provisions made by the State Government as a part of revenue expenditure. Besides, all the irrigation projects are treated similarly for financing the operation and maintenance. In case of the irrigation projects completed through the World Bank finance, however, thee norms are on a higher size so as to meet the obligations arising out of the agreement between the State Government and World Bank.

Per Hectare Budget Allocation for Operation and Maintenance

Once the irrigation project is completed and goes into the operation and maintenance phase, the provision for operation and maintenance is made in the non-plan sector of the annual budget. The budget provision for the purpose is made on the basis of the following norms which have been laid down in 1980 based on the 1980 cost:

a. Rs. 80 per hectare of the irrigation potential on the World Bank-aided irrigation projects (inclusive of establishment charges);

b. Rs. 60 per hectare of the irrigation potential on all old and new irrigation projects in the State with gated spillways (inclusive of establishment charges); and

c. Rs. 50 per hectare of the irrigation potential on all old and new irrigation projects in the State with ungated spillways (inclusive of establishment charges).

The establishment cost component of the norms has been assumed at 30 percent of the norm. In practice, however, the provision for establishment is made on the basis of the trend of actual expenditure on establishment and related aspects. The weighted average cost of operation and maintenance as per above norms works out to Rs. 60 per hectare of irrigation potential created. Of this the establishment cost component is taken to be one-third, i.e, at Rs. 20 per hectare.

The total budget provision for operation and maintenance would thus depend on the total irrigation potential created for use in a particular year and not as a fixed proportion of the total irrigation budget.

Staffing Levels for Operation and Maintenance of Irrigation Projects

The State of Maharashtra has been divided into six regions for the purpose of construction of new irrigation projects and operation and maintenance of existing irrigation systems. The distribution of districts in the individual regions is indicated in Table 4.5.

The Chief Engineer is in charge of one region and he has to coordinate the activities relating to construction of irrigation projects, operatin and maintenance of irrigation systems and monitoring and evaluation. Separte wings are created under the Chief Engineer to look after these activities.

Each of the regions is divided into 3 to 5 circles, depending upon the river basins and subbasins and number of irrigation projects (both under construction and in operation) in each region. The Superintending

Table 4.5: Distribution of Districts in Individual Regions.

Region	Districts
1. Konkan	Thane, Raigad, Ratnagiri, Sindhudurg
2. Pune	Pune, Satara, Sangli, Kolhapur, Solapur
3. Nasik	Nasik, Ahmednagar, Dhule, Jalgaon
4. Aurangabad	Aurangabad, Beed, Parbhani, Jalna, Latur, Nanded, Osmanabad
5. Amaravati	Buldhana, Akola, Yavatmal, Amaravati, Warda, Chandrapur, Gadchiroli
6. Nagpur	Nagpur, Bhandara

Engineer is in charge of the circle. He has to look after the activities of construction of irrigation projects, operation and maintenance of irrigation systems and monitoring and evaluation of irrigation projects in the circle. The separation of these activities really start from the circle level. In that, so far as operation and maintenance of irrigation systems are concerned, the individual circle is divided into 2 to 4 divisions and the Executive Engineer in charge of the division is responsible for operation and maintenance of irrigation systems. Similarly, the Executive Engineers in charge of construction activities work under the Superintending Engineer of the concerned cirlce.

As stated earlier, each of the divisions responsible for operation and maintenance of irrigation systems is divided into 4 to 6 subdivisions and each subdivision is composed of 4 to 6 sections. The subdivision headed by a Deputy Engineer and the section is headed by a Junior Engineer.

Thus, there exists a separate cadre of staff at the division, subdivision and section levels for operation and maintenance of irrigation systems. The original staff norms prescribed in the year 1968 have been changed in the year 1982. The staff norms for operation and maintenance of irrigation systems prescribed during the years 1968 and 1982 are given in Annex II separately for the division, subdivision and section levels.

Objectives of Collecting Water Charges

The primary objective of the Government in collecting water charges from the farmers and other beneficiaries is to obtain revenue from water

rates to be able to recover the cost on account of operation and maintenance of irrigation projects and to provide in addition, 1 percent return to the Government to meet the depreciation cost of the project.

Keeping in view the losses being incurred by the irrigation projects in the country, the Eighth Finance Commission has mentioned in para. 3.18 of its report that irrigation projects should at least recover the cost on operation and maintenance through there may not be any return on investments in these projects in the forecast period. Similar view was held in the Seventh Conference of the Irrigation Ministers held in December 1982.

Table 4.6 gives information on actual expenditure on operation and maintenance of irrigation projects in Maharashtra and the revenue receipts for the period of five years.

Considering the irrigation charges along with other receipts (viz., Employment Guarantee Scheme and Education cesses), it is seen that the revenue receipts exceeded the actual working expenses on the irrigation projects in Maharashtra.

Table 4.6: Actual Working Expenses on Operation and Maintenance and Revenue Receipts of Irrigation Project in Maharashtra.

(Rs. in lakhs)

Particulars	1979-80	1980-81	1981-82	1982-83	1983-84	Total
1. Working Expenses						
a. Establishment	598	722	797	947	1160	4224
b. Works	458	554	769	845	1084	3710
Total	1056	1276	1566	1792	2244	7934
2. Revenue Receipts						
a. Irrigation water charges	970	1057	1130	1122	1313	5592
b. Other water	253	116	316	349	260	1294
c. Employment guarantee scheme cess on irrigated areas	156	177	191	175	216	915
d. Education cess on irrigated areas	178	199	214	201	130	1022
Total	1557	1549	1751	1847	1919	8623

Source: Office Records of Irrigation Dept., Govt. of Maharashtra.

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5. SYSTEM LEVEL STUDY OF OPERATION AND MAINTENANCE OF IRRIGATION PROJECTS

The present chapter is devoted to discussing in detail the aspects of systems characteristics, systems operation, paying for operation and maintenance and water charges-incremental farm income relationship to the average irrigation systems of three types, i.e., major, medium and minor. The system level and farm level data/information of the year 1983-84 has been used for studying these aspects.

Systems Characteristics

The frequency distribution of the sample irrigation systems is given in Table 5.1 according to different age classes of the irrigation systems.

The sample irrigation systems have been completed at different time periods. The age of the average irrigation system worked out to be 37, 22 and 23 years in case of the major, medium and minor irrigation systems, respectively.

Important Features of the Irrigation Systems

Table 5.2 presents information relating to some of the features of the average irrigation system. The features of the average systems belonging to individual categories are self-explanatory.

Table 5.1: Frequency Distribution of the Sample Irrigation Systems According to Age Classes.

System types	Number of systems in age classes					Average age (years)
	Less than 10 years	10 to 20 years	20 to 30 years	30 to 40 years	Above 40 years	
Major	1	1	-	1	2	37
Medium	1	2	1	1	-	22
Minor	1	1	2	1	-	23
Total	3	4	3	3	2	27

Table 5.2: Information of Important Features of the Average Irrigation Systems.

Particulars	Major project	Medium project	Minor project
1. Length of main canal (Kms)	95.98	25.13	6.47
2. Length of branch canal (Kms)	69.64	29.54	2.70
3. Length of distributaries (Kms)	387.20	40.71	1.50
*4. Command area (ha)	73557.20	8357.40	658.40
5. Number of villages in command	154.00	27.00	5.00
6. Number of operating sections	15.40	2.20	0.40

History of Rehabilitation of the Systems

It was rather difficult to obtain detailed information on major rehabilitation in case of the old irrigation systems. At the same time, it was reported that the new irrigation systems did not require major rehabilitation programs. The minor rehabilitation programs, however, included the activities of repairs to canals, branches, distributaries and field channels, removal of trees and bushes, etc., and the same where performed as and when required. No separate account of expenses on these activities was available.

Seasonwise Area Irrigated in the Command

The details of the total command area irrigated during individual crop seasons are given in Table 5.3 for the average irrigation systems.

Of the total command area of 73557.20 hectares, 8357.40 hectares and 658.40 hectares of the major, medium and minor irrigation projects, respectively, about 30 to 45 percent area was irrigated by the systems, the lowest and the highest proportions being for major and minor projects. About 17 percent of the command area was irrigated in rabi season and 8 percent in hot weather season in case of the major irrigation projects. In case the medium irrigation projects 24 percent

Table 5.3: Seasonwise Area Irrigated in the Command of the Average Irrigation Systems.

(Hectares)

Particulars	Major project	Medium project	Minor project
Total area in the command	73557.20 (100.00)	8357.40 (100.00)	658.40 (100.00)
Total irrigated area	27974.49 (38.03)	3706.46 (44.35)	293.40 (44.56)
(a) Kharif season	6495.80 (8.83)	751.31 (8.99)	41.60 (6.32)
(b) Rabi season	12259.80 (16.66)	2012.71 (24.08)	225.60 (34.26)
(c) Hot weather season	6176.19 (8.40)	725.58 (8.69)	26.20 (3.98)
(d) Perennial	3042.70 (4.14)	216.86 (2.59)	- -

(Figures in the parentheses are percentages to the total command area.)

of the command area was irrigated in rabi season and 9 percent in hot weather season. Contrary to this, about 34 percent of the command area was irrigated in rabi season and 4 percent in hot weather season in case of the minor irrigation project. The area irrigated in kharif season ranged between 6 and 9 percent of the total command area in case of all the irrigation projects. The supply of irrigation water for annual and perennial crops was observed only in case of the major and medium irrigation projects and the proportion of such area was 3 to 4 percent of the total command area.

Ownership of Water and System Facilities

The ownership of water and system facilities is vested with the State Government. The distribution of irrigation water among the farmers is managed with the help of the staff in the Irrigation Department separately meant for operation and maintenance of irrigation systems.

Availability and Use of Water in Different Seasons

The details of the availability and use of water in different seasons are given in Table 5.4 for the average irrigation systems.

The use of water for irrigation has been observed to be relatively more in rabi and hot weather seasons in case of the major and medium irrigation projects. On the contrary, the availability of water for irrigation was observed in kharif and rabi seasons only in case of the minor irrigation projects.

The limited use of irrigation water in kharif season was due to the constraint on availability of water in the reservoir at the time of effecting kharif sowings.

Table 5.4: Details of Availability and Use of Water for the Average Irrigation Systems.

(Million cubic feet)

Particulars	Major project	Medium project	Minor project
1. Designed storage capacity	17940	2386	122
2. Carryover for next year	3080	165	-
3. Actual storage on 1 July	2124	212	24
4. Actual storage on 15 October	17438	1829	114
5. Actual storage on 1 March	10867	1118	40
6. Maximum storage observed	17681	1754	112
7. Water used for kharif irrigation	2206	206	26
8. Water used for rabi irrigation	9747	632	76
9. Water used for hot weather irrigation	7800	610	-
10. Water used for lifts	155	86	-
11. Water for domestic use	3598	28	-
12. Water allowed to flow through river course	12346	103	-

Projected and Actual Area Irrigated in Different Seasons

Table 5.5 presents the details of seasonwise projected and actual area irrigated in the command of average irrigation systems.

The critical examination of the figures given in Table 5.5 reveals that there existed wide variations in the projected and actual area irrigated in all the seasons for different types of irrigation systems. It is rather difficult to point out a specific reason for such wide variations in the projected and actual area irrigated. Perhaps defects in choosing the base for setting projections of irrigated area and underutilization of available irrigation in kharif and rabi seasons resulting from several inefficiencies in irrigation water use at the system and farm levels could be thought of as the probable reasons for these variations. The actual area irrigated for growing hot weather and perennial/annual crops was quite a bit higher than the projected area irrigated in case of the major and medium projects. Mostly the water left over in the reservoirs after meeting the demand for kharif and rabi crops seems to have been used advantageously for irrigating areas under hot weather and perennial/annual crops.

If we reconcile the information given in Tables 5.4 and 5.5, it could be concluded that adequate water was not available in kharif and

Table 5.5: Seasonwide Projected and Actual Area Irrigated in the Command of Average Irrigation Systems.

(Hectares)

System types	Projected/ Actual	Kharif season	Rabi season	Hot weather season	Perennial	Total
Major	Projected	19347.20	20155.20	3339.40	2539.00	45380.80
	Actual	6495.80	12259.80	6176.19	3041.70	27974.49
		(33.57)	(60.83)	(184.95)	(119.84)	(61.64)
Medium	Projected	3618.80	3080.60	641.00	294.00	7634.40
	Actual	751.31	2012.71	725.58	216.86	3706.46
		(20.76)	(65.33)	(113.20)	(73.76)	(48.55)
Minor	Projected	250.60	352.20	60.20	-	663.00
	Actual	41.60	225.60	26.20	-	293.40
		(16.60)	(64.05)	(43.52)	-	(44.25)

(Figures in parentheses indicate percentages of actual irrigated area to projected irrigated area.)

rabi seasons in case of all the irrigation systems. The inquiries with the sample farmers further made it clear that the irrigation water supplies were not predictable and reliable in kharif season and they used irrigation water for supplemental irrigation to the foodgrain crops grown in rabi season.

Number of Farms and Average Farm Size

The information on the number of farms served and total area owned by the farms per average irrigation system is given in Table 5.6 according to different size classes of farm holdings.

The average major, medium and minor irrigation systems served 18075, 3996 and 203 farms, respectively, and the total area owned by these farms was 52645.00 ha, 7417.99 ha and 572.60 ha. At the overall level the average farm size worked out to 2.91 ha, 1.86 ha and 2.82 ha in case of the major, medium and minor irrigation systems, respectively.

Table 5.6: Number of Farms Served and Average Farm Size in the Command of the Average Irrigation Systems.

Size class and particulars	Major project	Medium project	Minor project
Less than 2 hectares			
(a) Number of farms	8527.00	2913.00	109.00
(b) Total area owned (ha)	11940.40	3405.15	196.20
(c) Average farm size (ha)	1.40	1.17	1.80
2 to 4 hectares			
(a) Number of farms	4614.00	694.00	46.00
(b) Total area owned (ha)	14342.60	1860.59	116.80
(c) Average farm size (ha)	3.11	2.68	2.54
Above 4 hectares			
(a) Number of farms	4934.00	389.00	48.00
(b) Total area owned (ha)	26362.00	2152.25	259.60
(c) Average farm size (ha)	5.34	5.53	5.41
Total (a) Number of farms	18075.00	3996.00	203.00
(b) Total area owned (ha)	52645.00	7417.99	572.60
(c) Average farm size (ha)	2.91	1.86	2.82

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From the classification of the farms into three size classes (i.e., less than 2 ha, 2 to 4 and above 4 ha), it was observed that the average farm size ranged between 1.40 to 5.34 ha in major irrigation project command, between 1.17 to 5.53 ha in medium irrigation project command and between 1.80 and 5.41 ha in minor irrigation project command.

Cropping Pattern and Crop Yields

Table 5.7 presents the cropping pattern in irrigated command area of the average irrigation system along with per hectare yields of different crops.

Table 5.7: Cropping Pattern and Average Crop Yields in the Irrigated Command of the Average Irrigation Systems.

Crop	Major project		Medium project		Minor project	
	Area (ha)	Yield (qtls/ha)	Area (ha)	Yield (qtls/ha)	Area (ha)	Yield (qtls/ha)
1. Paddy	2043	15.47	272	11.52	6	9.47
2. Khar	5726	19.96	1361	17.51	204	12.34
3. Rabi jowar	8644	11.62	264	16.33	159	13.80
4. Bajra	8498	14.75	259	10.25	35	8.58
5. Wheat	8307	16.04	1408	14.96	37	14.50
6. Gram	790	9.84	416	8.00	8	9.84
7. Maize	577	13.00	68	-	-	-
8. Kharif groundnut	4872	12.78	783	14.00	68	11.50
9. Summer groundnut	2847	18.46	1336	17.55	29	14.50
10. Chillies	2924	-	54	-	-	-
*11. Banana	819	15.44	-	-	-	-
*12. Sugarcane	2101	103.60	404	110.30	-	-
13. Cotton	9187	11.90	1776	12.69	11	8.65
14. Other crops	1274	-	216	-	34	-
Gross cropped area	58610		8617		591	
Net cropped area	45682		6935		513	
Cropping intensity (percent)	128.30		124.25		115.20	

*Yield in tons per hectare.

Among the foodgrain crops, jowar (kharif and rabi), bajra and wheat are the important crops. The commercially important crops grown in the area are groundnut (kharif and hot weather), cotton and sugarcane.

No separate crop yields were available for the crops grown under irrigated and rainfed conditions. However, the farm level crop yield estimates revealed that the yield levels of crops such as jowar, bajra, wheat, cotton and groundnut were almost 2 to 3 times higher when grown under irrigated conditions as compared to the yield levels for rainfed conditions.

The cropping intensity worked out to 128.30, 124.25 and 115.20 percent in the areas served by major, medium and minor irrigation systems, respectively.

Annual Rainfall

Table 5.8 presents the details of annual rainfall in the command of the average irrigatin systems.

The annual rainfall ranged between 543 to 1200 mm among the command areas of the sample irrigation systems. The average annual rainfall was 946, 740 and 712 mm in the command of the average major, medium and minor irrigation systems.

The annual rainfall ranged between 543 to 1200 mm among the command areas of the sample irrigation systems. The average annual rainfall was 947, 740 and 712 mm in the command of the average major, medium and minor irrigation systems.

Systems Operation

The systems operation has been described below with special reference to the existing method of delivering water, farmers' complaints and involvement of officials and water user organizations for operation and maintenance at different levles of the system.

Table 5.8: Annual Rainfall in the Command of the Average Irrigation Systems.

(mm)

System type	Rainfall range	Average annual rainfall
Major	625 to 1200	946
Medium	543 to 920	740
Minor	560 to 875	712

Method of Delivering Irrigation Water

The rotational method of delivering irrigation water has been adopted in cases of all the sample irrigation systems under study. In that, the water is allowed to flow through canals and the same is delivered to the users at fixed intervals. The dates of delivering irrigation water are notified well in advance and water is supplied to the farms with field to field method on rotation.

The rotation intervals are determined depending upon the type of irrigation blocks sanctioned on a particular distributory and seasonal conditions. The interval period usually remains quite long with less concern about water requirement of crops. This practice has usually resulted in the increased tendency of farmers to use excessive irrigation for the crops without bothering about the consequent ill effects of excessive irrigation.

Farmer Complaints

The major complaints of the farmers related to timely supply of irrigation water and obtaining sanction for the irrigation block desired. The complaints with regard to the difficulties in obtaining for the irrigation blocks were made firstly to the Section Officer and then to the Deputy Engineer in charge of the division. It was reported in certain cases that farmers used to take help of local leaders in getting the problem solved.

The complaints relating to timely supply of irrigatin water were usually made to the Canal Inspectors and help of Section Officer was taken under the circumstances when the complaints remained unattended at the level of Canal Inspector.

The officials responsible for operation and maintenance of the irrigation systems reported that they receive complaints quite often in large number. However, from the point of view of giving benefits of limited irrigation water to a maximum number of farms on equitable basis within the framework of government policy, it becomes difficult for them to attend all such individual complaints positively. Many times the officials remained prompt in attending to the geunuine complaints.

Responsibility of Operation and Maintenance

The existing arrangement for operation and maintenance of irrigation systems in the State has already been discussed earlier. A similar pattern was observed in case of the sample irrigation systems.

For the major irrigation systems, the Superintending Engineer is responsible for operation and management of the system and he is assisted

by the Executive Engineer at the division level, Deputy Engineer at the Subdivision level and Junior Engineer at the section level. At the grass root level, the Canal Inspectors are looking after the activities of distribution of irrigation water to beneficiaries, maintenance of field channels, drainage works, etc.

In case of the medium irrigation projects, the Deputy Engineer is in charge of the system and he seeks guidance of the Executive Engineer in the matters relating to operation and maintenance of the system. He is assisted by the Junior Engineers and Canal Inspectors at the section and field levels.

The Junior Engineer is in charage of the minor irrigation project. He is guided by the Deputy Engineer of the Subdivision. At the field level he is assisted by the Canal Inspectors in operation and maintenance of the system.

Water User Organizations

Though there is a provision for formation of water user organizations, no formal organizations of water users were observed in case of all the sample irrigation systems. The Canal Advisory Committees, however, meet periodically to render guidance to the officials in the matters of operation of the systems. A few informal organizations of water users were reported to be active in maintaining field channels at limited places.

When inquired of the sample farmers, it was reported that there was a need for having water user organizations for allocating water and maintaining field channels. Quite a few farmers expressed doubts about the effectiveness of such organizatins due to probable interference of political forces.

From the farm level study, a few examples were observed wherein farmers provided free labor for maintaining field channels.

Paying for Operation and Maintenance

The efficiency of operation and maintenance of the irrigation systems needs to be judged on the basis of the comparison of recurrent costs with revenue receipts realized through collection of water charges. An attempt is made in this section to discuss in brief the various aspects relating to recurrent costs of operation and maintenance and revenue receipts of the irrigation systems included in the sample. Wherever required, the farm level data have been used to work out estimates of some of the variables to supplement observations at the system level.

Types and Amounts of Water Rates

The water rates of individual crops are charged on a per hectare irrigated basis and these rates remain common for all the irrigation systems in the State sufficiently for a long period of a decade or more. Table 5.9 presents the per hectare water rates of different crops for the years 1960-61, 1970-71, 1975-76 and 1983-84.

The water rates of different crops, which were fixed during 1960-61, continued to be the same for a period of fifteen years. The present water rates were brought in force from the year 1975-76.

The farmers are required to pay the amount of water rates directly to the Irrigation Department. In addition to the water rates, the farmers are required to pay extra charges on account of Employment Guarantee Scheme and Education cesses imposed by the State Government since the last decade in the proportion of 1 percent and 10 percent of the water rates, respectively. These payments are made to the Revenue Department at the time of paying annual land revenue taxes on the land owned by the farmers.

From the farm level study it was observed that some of the farmers incurred additional informal expenditure on entertainment and other accounts besides paying formal water charges (inclusive of water rates and cesses). However, such cases were rare and difficult to quantify.

Table 5.9: Per Hectare Water Rates for Different Crops.

(Rupees)

Crop	Per hectare water rates in			
	1960-61	1970-71	1975-76	1983-84
1. Kharif jowar	15.00	15.00	50.00	50.00
2. Paddy	15.00	15.00	50.00	50.00
3. Bajra	15.00	15.00	50.00	50.00
4. Groundnut	30.00	30.00	100.00	100.00
5. Rabi jowar	22.50	22.50	75.00	75.00
6. Wheat	22.50	22.50	75.00	75.00
7. Gram	22.50	22.50	75.00	75.00
8. Summer groundnut	-	-	300.00	300.00
9. Cotton	75.00	100.00	250.00	250.00
10. Sugarcane	300.00	450.00	750.00	750.00
11. Plantation Crops	300.00	450.00	750.00	750.00

Proportions of Farmers Paying Water Rates

All the farmers taking benefit of irrigation water from irrigation systems are required to pay the amount of water rates regularly. Yet some farmers do not pay the amount in time or some others pay only a part of the total amount. Table 5.10 indicates the proportions of farmers paying water rates in time, along with the recovery percentages for the average irrigation systems.

The proportions of farmers paying water rates in the ranges between 51.45 and 63.84 percent, the lowest and the highest proportions being in case of the minor and major irrigation systems, respectively. Similarly, the amount of water charges collected during the year was 67.12, 64.49 and 58.33 percent of the total amount, respectively, in case of the major, medium and minor irrigation systems.

Cost Recovery Index

The data on total amount of water charges, amount of water charges received, other receipts and costs on operation and maintenance of irrigation system were obtained for three years from 1981-82 to 1983-84 for the sample irrigation systems. The details of the annual receipts and recurrent costs of the average irrigation systems are given in Annex III.

Based on the details of recipts and recurrent costs as given in Annex III, the cost recovery indexes have been worked out and the same are presented in Table 5.11.

Table 5.10: Proportions of Farmers Paying Water Rates in Time and Water Rates Collection Percentages for the Average Irrigation Systems.

System type	Percentage of farmers paying water rate in time	Percentage of amount of water rates collected during the year
Major	63.84	67.12
Medium	68.23	64.49
Minor	51.45	58.33

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Table 5.11: Cost Recovery Indexes of the Average Irrigation Systems.

Particulars	Year	Major project	Medium project	Minor project
1. Total water charges as percentage of total cost	1981-82	173.53	100.18	137.50
	1982-83	146.67	111.11	138.46
	1983-84	132.81	96.03	113.79
2. Total water charges and other receipts as percentage of total cost	1981-82	175.44	107.22	137.79
	1982-83	149.89	118.87	138.46
	1983-84	135.51	100.13	113.79
3. Amount of water charges collected as percentage of total cost	1981-82	81.55	50.88	91.67
	1982-83	90.99	67.73	60.71
	1983-84	88.84	61.92	65.52
4. Total annual receipts as percentage of total cost	1981-82	99.61	121.30	116.67
	1982-83	100.22	94.37	67.86
	1983-84	102.82	96.03	86.21

The cost recovery indexes varied considerably during the period of three years for the sample irrigation systems. The overdues of water charges have resulted in keeping down the cost recovery indexes at a lower level. If the cost recovery indexes are estimated by considering total water charges as the percentage of total recurrent cost, the same give encouraging picture relating to functioning of the irrigation systems. However, this could become a reality only on increasing the efficiency level of collecting water charges.

Comparison of Changes in Water Rates and General Price Index

Table 5.12 presents the comparison between changes in water rates index and general price index over the priod from 1970-71 to 1983-84.

The comparison of charges in water rates index and general price index reveals that the increase in water rates of foodgrain crops was more than proportionate as compared to the increase in general price index. The increase in water rates of cash crops was, however, less than proportionate in relation to the increase in general price index. It may be mentioned here that the water rates prevalent in 1970-71 were fixed in the year 1960-61.

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Table 5.12: Changes in Water Rates Index and General Price Index.

Year	Water rates index		General price index
	Foodgrain crops	Cash Crops	
1970-71	100.00	100.00	100.00
1975-76	333.33	250.00	172.90
1980-81	333.33	250.00	257.30
1982-83	333.33	250.00	288.60

Method and Time of Collection of Water Rates

As prescribed by the Irrigation Department, the farmers are required to pay water rates of the crops grown in different seasons in lump-sum on or before the dates as indicated below.

1. Kharif season crops - 31 May of following year
2. Rabi season crops - 31 August of following year
3. Hot weather crops - 31 January of following year

The water rates are collected in the office of the individual sections.

Link Between Water Rates and Operation and Maintenance Services

It has been observed that the costs on account operation and maintenance were not considered for deciding water rates. On the contrary, the water rates were fixed on per hectare irrigated basis of different crops depending upon their incremental income levels when grown under irrigated conditions. However, fixation of water rates was not done very often, as it involved some difficulties.

The sample farmers reported that the yield levels and incremental income of the crops grown undr irrigated conditions are quite high as compared to the rainfed crops. They would not consider water rates as a burden so long as irrigation water supply remained timely and in adequate quantities.

Factors Helping Collection of Water Charges

The following factors were reported to be helpful for the most successful efforts to collect water rates:

1. Government rules for sanction of application for supply of irrigation water on payment of water charges of previous year;

2. Imposition of penalty for non-payment of water charges on prescribed data;

3. Good services; and

4. Close contact with the farmers.

Among the above factors, the former two have been observed to be the most important for helping the collection process. This observation was supported substantially by the farm level inquiry.

Spending for Operation and Maintenance

Table 5.13 presents information on per hectare norms and actual expenditure incurred on operation and maintenanance of the sample irrigation systems.

It is evident from the table that the per hectare actual expenditure incurred was quite higher than the prescribed norms for operation and maintenance of the irrigation systems. The amount needed for effecting improvements in operation and maintenance would necessarily be higher than the existing expenditure level. The sample farmers opinioned that they would readily meet a part of incremental expenditure on account of improved operation and maintenance provided such improvements help them in getting timely and adequate water supplies.

Table 5.13: Per Hectare Norms and Actual Expenditure for Operation and Maintenance of Irrigation Systems.

(Rs. per hectare)

System type	Prescribed norm	Actual expenditure
Major	60.00	261.06
Medium	60.00	210.44
Minor	50.00	98.84

Penalty for Non-Payment of Water Charges

The following penalty measures were adopted for non-payment of water charges.

1. An extra penalty of 10 percent on the amount of water charges is recovered from the farmers for non-payment of water charges in time;

2. The application for sanction of irrigation water supply for the next season is refused and it is considered only after effecting payment of all the dues of water charges; and

3. In case of non-payment of water charges as per above provisions, the arrears of water charges are recovered through coercive measures by resorting to the provisions made under the Maharashtra Land Revenue Code.

Water Charges and Incremental Farm Income

The estimates of incremental farm income and cost on account of irrigation water charges are given in Table 5.14 on per farm basis. These estimates are worked out on the basis of the costs and returns structure of crop production activities of the sample farms for two different situations, i.e., irrigated and rainfed.

The per farm cost of irrigation water charges was 12.03 percent of the incremental income of the sample farms.

Table 5.14: Per Farm Water Charges and Incremental Farm Income of the Sample Farms.

Particulars	Amount (Rs.)
1. Cost of irrigation water charges	852.66
2. Incremental cost of crop production	4577.62
3. Incremental gross income	11663.20
4. Incremental farm income	7085.58
5. Irrigation water charges as percentage of incremental farm income	12.03

6. CONCLUSIONS

Based on the foregoing discussions, the study concludes that:

1. The State Government has given due attention for operation and maintenance of irrigation systems by way of creating a separate wing for the purpose. The operation and maintenance mechanism is, however, not sufficient for scientific use of irrigation water at the system and farm levels;

2. As a result of several inefficiencies inherent with the operation and maintenance mechanism, quite a large proportion of irrigation water resource remains unutilized;

3. The State Government has set definite procedures for fixing water rates, norms for operation and maintenance of cost, sanction of water demand application, collection of water charges, formation of water user organizations, etc. There are, however, some drawbacks in execution of these procedures. In that, the water rates are not revised from time to time and the norms for operation and maintenance cost are quite low as compared to the amount actually spent for the purpose;

4. The estimates of water availability and projected area for irrigation in different seasons need to be worked out on a scientific basis for the individual irrigation systems; and

5. The farmers expect prompt services of water supply. They would respond positively for paying higher water rates under situations of assured water supply.

Annex I

Canal Advisory Committees and Water
Panchayat Committee;
(Establishment of the) on the
Various Canal Systems.

GOVERNMENT OF BOMBAY.
PUBLIC WORKS DEPARTMENT.
Resolution No. 3647/36 - II.
Bombay Castle (Bombay No. 1), 17 May 1951.

Read Government Resolution No. 3647/36-II
dated 30 May 1947.

Letter No. G.R. 49 dated 17 February 1949 from
the Superintending Engineer, Southern Circle.

Letter No. P.F.-51/5017 dated 7 June 1950 from
the Superintending Engineer, Deccan Irrigation Circle

RESOLUTION: On the recommendations of the local officers, Government is pleased to revise the Constitution and Rules of Business of Canal Advisory Committees and Water Panchayat Committess. The accompanying revised rules will come into force hereafter.

By order of the Governor of Bombay.

Sd/x-x-x-
V.W. GOTHOSAKAR,
Deputy Secretary to Government

To:

The Finance Department
The Revenue Department
The Agriculture and Forests Department
The Development Department
The Chief Engineer, Public Works Department
The Superintending Engineers of Circles
All Collectors of Districts
The Accountant General, Bombay
The Deputy Accountant General, Baroda
The Executive Engineers in charge of Irrigation Works
The Director of Publicity

No. of 1951

Copy forwarded and guidance to

Accompaniments to Government Resolution, Public Works Department

No. 3647/36-II dated 17 May 1951

CONSTITUTION AND RULES OF BUSINESS OF CANAL ADVISORY COMMITTEES

Rules

1. These Rules may be called "The Canal Advisory Committee Rules, 1947."

2. In these rules:

a. "Canal Advisory Committee" shall mean the "Committee" constituted in accordance with the rules.

b. "Executive Engineer" shall mean the Executive Engineer of the Public Works Department Division" concerned or any other officer deputed by him in this regard by a general or special order.

c. "Subdivisional Officer" shall mean the "Subdivisional Officer of the Public Works Department Subdivision" concerned.

3. Subject to the approval of the Superintending Engineer the activities of a Canal Advisory Committee will extend over the entire area served by one (or more) specific irrigation system, provided that no Committee shall have to deal with more than one Executive Engineer.

4. The whole body of irrigators in the sphere of activities of each Committee will constitute a "Bagaitdar Sangh" and every irrigator will ipso facto be a member of the Sangh as long as he holds a valid pass for irrigation on the irrigation system concerned.

5. The composition of the Canal Advisory Committee shall be as under:

Chairman-
Executive Engineer-
Member-

a. One representative of the Agricultural Department.

b. One representative of the Revenue Department.

c. One representative of the Sugar Factories nominated by the Deccan Sugar Factories Association.

d. Two local irrigators for each canal nominated by Government.

e. Two local members of Legislative Assembly or members of Legislative Council nominated by Government. The Subdivision Officers concerned will be present at the meetings but will not be members of the Committee.

Secretary-

The Executive Engineer may select one of the Subdivisional Officers mentioned above as the Secretary (non-member).

6. The non-official members will hold office for two years. The retiring members will, however, be eligible for renomination.

7. The functions of the Committee will be strictly advisory and will generally cover the following items:

a. The exchange of views on the needs of irrigated crops as regards the quantity of water required, irrigation intervals, dates of plantation and harvest, etc.

b. The collection and distribution amongst irrigators of information about new varieties of crops.

c. Suggesting measures for improving the supply of seed and the prevention and eradication of crop pests and diseases.

d. Submission to the Irrigation Department of information and requests in respect of (a) and (c) above.

e. Maintenance of a continuous liaison with the Water Panchayats operating on the canals concerned.

f. Receiving petitions, appeals, etc. of a general nature from Water Panchayats and discussing same.

g. Holding Irrigators' Conference in January every year when demonstrations, exhibitions and lectures by experts on irrigation, agriculture, cooperation, etc., may be arranged.

(Note: The Committee will have no authority to inquire into or interfere with the internal administration and working of the Irrigatin Department or with questions of personnel and discipline; and if any question arises at any meeting as to the validity of a matter raised for discussion, the decision of the Chairman will be final.)

8. The Chairman will ordinarily convene meetings of the Committee at least three times a year. The dates of the meetings should be so arranged that there is at least one meeting in each of the kharis, rabi and hot weather seasons. The notice for such meetings will not be less than ten days. The Chairman will be at liberty to request any other

persons, official or non-official, to attend any meeting of the Committee whenever their presence and advice appear to him to be desirable. The person or persons so invited will, however, have no right of voting.

9. Any subject relating to irrigation on the canals concerned may be brought up for discussion by any member of the Committee.

10. The agenda for each meeting shall be circulated to all members ten days before the data of such meeting and it will include all items received and approved by the Chairman up-to-date; urgent business may, however, be taken for consideration at any meeting without notice, with the consent of the Chairman.

11. The Chairman will keep the Superintending Engineer informed from time to time regarding work done by the Committee.

12. Non-official members of the Committee will be eligible for traveling expenses under the rules in Appendix XLII-A of the Bombay Civil Services Rules Manual as amended from time to time.

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CONSTITUTION AND RULES OF BUSINESS OF A WATER PANCHAYAT COMMITTEE

Rules

1. These Rules may be called "The Water Panchayat Committee Rules, 1947."

2. In these rules:

a. "Panchayat Committee" shall mean the "Panchayat Committee" constituted in accordance with the following rules.

b. "Group" means the "particular group of Irrigators" as defined in Rule No. 3.

c. "Executive Engineer" shall mean the "Executive Engineer of the Public Works Department Division" concerned or any other Officer deputed by him in this regard by a general or special order.

d. "Subdivisional" Officer" shall mean the "Subdivisional Officer of the Public Works Department Subdivisional" concerned.

3. The sphere of activities of each Panchayat Committee shall ordinarily be equivalent to the beat of a Canal Inspector and the Executive Engineer shall have the power to fix its exact limits in each

particular case. All the irrigators within this limit shall be collectively termed the "Group of Irrigators."

4. Each Panchayat shall consist of three to seven Panchas, and the Executive Engineer shall have the power to fix the exact number in each case and also to nominate additional Panchas to secure sufficient representation of small bagayatdars and also of bagayatdars at the tail on the Panchayat Committee.

5. At a meeting held in accordance with Rule 8, the group shall elect candidates for being appointed as Panchas and number to be elected shall be double the number of vacancies to be filled. The names of all the elected candidates shall be arranged to descending order of number of votes secured by each, and from the list so prepared, the first half shall be appointed as Panchas.

6. Panchas* shall be appointed for a period of two years. About half the number of Panchas shall retire in rotation each year. Elections shall be held each year for the purpose of filling such vacancies. The retiring Panchas will be held eligible to contest the new elections.

(Explanation: When a Panchayat is newly established, about half the number of Panchas in the order of votes secured will be appointed for two years and the result for only one year.)

7. If any Panch retires before the expiration of is term of office, the vanacy so caused shall be filled by appointing the next available elected candidate on the list prepared as laid down in Rule No. 5 above. When no such candidates are available, the required number will be elected in accordance with the provision of Rules No. 5 and 8.

8. For the purpose of holding the elections of candidates for being appointed as Panchas, the Subdivisional Officer shall convene a meeting of the group with a notice of not less than seven days as regards date, time and place thereof. The elections shall be made by majority of votes of eligible bagayatdars in the group under the supervision of the old Sarpanch or another President specially elected at the meeting. The President shall communicate to the Subdivisional Officer within three days the results of such elections, failing which the Subdivisional Officer shall assume that the elections were not held and shall then take such further action as would appear to him necessary.

9. Any bona fide irrigator who has had sanction of irrigation in the preceding year within the limits of the Group concerned shall be eligible to vote at the election meetings, provided he attends the meeting in person.

10. Any bona fide irrigator who has had sanction of irrigation in the preceding year within the limits of the Group at the time of an election shall be eligible to contest for the seat of Panch.

11. A Panch shall cease to be a Panch and vacate his seat in the Panchayat if he fails to have any sanction of irrigation on the Canal for a period of 12 months while water could have been made available to his land or if he takes water unauthorisedly to a crop not sanctioned under the Irrigation Rules. A Panch who takes water unauthorisedly should not be eligible for re-election for a period of two years.

12. As soon as the annual elections of new Panchas are declared, the old and new Panchas together shall elect Sarpanch for the ensuing year.

13. The business year of the Panchayat shall be reckoned from 15 February to 14 February. The election of Panchas for the ensuing year shall be held in the second fortnight of January.

*Panch: Member of Panchayat Committee. See Rule No. 9.

14. As soon as a Panchayat is constituted, it shall be held responsible for carrying out the following duties:

a. To prepare Pali-Patraks.

b. To estimate the quantity of water required in the ensuing rotation and inform the Subdivisional about it, so as to make it convenient for the latter to arrange for a suitable supply of water consistent with the interest and convenience of the Canal as a whole.

c. To advise the irrigators as necessary and to ensure that water is not used without a valid pass, out of turn, unauthorisedly or extravagantly and to prevent waste of water.

d. To hold panchamas, etc., in accordance with rules against those who commit such offenses as are mentioned in (c) above.

e. To settle mutually the complaints arising in connection with items (a) to (d) above and to communicate to the Subdivisional Officer, in writing, their disposal, together with the complainant's acceptance, of such disposal.

f. To offer suggestions to the Subdivisional Officer regarding equitable and economic distribution of canal water.

g. To disseminate among the Irrigators information regarding the latest Government orders and notifications concerning irrigation an agricultural matters.

15. The Sarpanch shall convene meetings of the Panchayat at a suitable place and from time to time as may be necessary, provided that the interval between any two such meetings shall not exceed three months. Representatives of the Irrigation and Cooperative Departments

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shall be requested to attend these meetings, though they shall not vote. The reports of the meeting shall be sent to the Subdivisional Officer in writing.

16. A Canal Inspector or Patkari appointed by the Executive Engineer shall continue to carry out all the duties mentioned in Rule 14 above, with the assistance of the Panchayat, for so long as the latter is not considered by the Executive Engineer to be fully capable of undertaking these duties independently.

17. The Panchayat shall be eligible after duly passing a resolution to that effect, to request the Executive Engineer to withdraw the Canal Inspector or the Patkari and if such demand is not fulfilled within six months, to appeal to the Superintending Engineer (Circle, whose decision in the matter shall be final).

18. If at any time it would appear to the Executive Engineer that the Panchayat is not satisfactorily carrying out the duties entrusted to it as mentioned in Rule 14 above, the Executive Engineer shall have the right again to depute a Canal Inspector or a Patkari for assisting the Panchayat, or to dissolve the Panchayat altogether and order fresh elections.

19. The Panchayat shall arrange to collect from the irrigators, at a rate not exceeding half an anna per rupee of the water rate payable by the Irrigators, funds necessary to meet its current or future expenditure. Any member who fails to contribute his share shall be disqualified and struck off the list of members.

20. The Panchayat shall be competent to appoint one or more paid servants for carrying out the clerical work in connection with the duties mentioned in Rule 14 above when it is functioning without the help of the Government Canal Inspector or Patkari. These servants will, however, not be entrusted with any administrative duties, which must be performed by the Panchayat itself.

21. The accounts of the Panchayat shall be maintained in a form approved by the Executive Engineer and shall be audited annually.

22. The funds of the Panchayat shall be deposited in a bank approved by the Registrar of Cooperative Societies.

23. The Panchayat can, after obtaining previous sanction of the Executive Engineer, also undertake the following functions in addition to those shown in Rule 1 above:

a. To disseminate, by means of propaganda among the Irrigators, knowledge regarding the improved practice and methods of irriculture in accordance with the suggestions of the Canal Advisory Committees.

b. To place in a collective form before the irrigation officers and Canal Advisory Committee the suggestions and complaints of irrigators in the Groups.

c. To collect the water applications of the irrigators and present them to the irrigation officers, after duly completing them, for facilitating their quick disposal.

Canal Advisory Committees and Water Panchayat Committees (Establishment of the) on the various Canal Systems

Government of Bombay
Public Works Department
Resolution No. CME. 1058-T
Sachivalaya, Bombay-1

Read: Government Resolution No. 3647/36-II dated 9 March, 17 May 1951

Letter No.: Gen/Irri/63856 dated 15 November 1958 from the Superintending Engineer, Gujarath Irrigation Circle

Resolution: On the recommendations of the local officers, Government is pleased to direct that the duration of a Canal Advisory Committee should be three years instead of two years, as hitherto.

1. Government is also pleased to direct that the non-official members will hold office for a period of three years instead of two years. Necessary corrections should accordingly be carried out in item 6 of the Constitution and Rules of Business of the Canal Advisory Committee printed as an accompaniment to Government Resolution, Public Works Department No. 3647/36-II, dated 17 May 1951.

2. Government is further pleased to direct that 50 percent of the representatives of local irrigation to be appointed to such committees should represent small irrigators.

By order and in the name of the Governor of Bombay.

Sd/x-x-x
(A.R. Kaulgud)
Officer on Spl. Duty.

Staff Norms for Operation and Maintenance of Irrigation Projects at Different Levels

Division Level

Staff Category	Number of posts 1968 norms	Number of posts 1982 norms	Remarks
Executive Engineer	1	1	
Deputy Engineer	1	1	
Tracer	1	1	
Assistant Tracer	-	2	
Draftsman	3	3	
Divisional Accountant	1	1	
Accounts Clerk	2	1 or 2	
Chief Accountant	-	1	
Auditor	-	1	
Assistant Superintendent	1	1	
Senior Clerk	1	1	
Junior Clerk	10	7 or 8	
Typists	-	3	
Record Keeper	1	1	One for each sub-division
Store Keeper	-	1	
Assistant Store Keeper	-	1	For store material value exceeding Rs. 3 lakhs
Store Clerk	-	1	For store material value exceeding Rs. 5 lakhs
Watchman	-	1	

Subdivision Level

Staff category	Number of posts	
	1968 norms	1982 norms
Deputy Engineer	1	1
Junior Engineer	1	2
Senior Clerk	1	3
Junior Clerk	2	2
Record Keeper	1	1
Attendants	3 or 4	3 or 4

Section Level

Staff category	Section with concentrated area irrigating more than 2000 hectares		Section with scattered area irrigating up to 2500 hectares	
	1968 norms	1982 norms	1968 norms	1982 norms
Junior Engineer	1	1	1	1
Branch Clerk	1	2	1	1 or 2
Mistri	1	2	1	1
Muster Keeper	2	2	-	-
* Canal Inspector	4	8	2	1 or 2
Record Keeper	1	2	-	-
Surveyor	3	4	2	2
Messenger	1	1	-	-
Junior Clerk	1	-	-	-
Patkari	2	-	2	-
* Choukidar	4	2	2	1 or 2
Attendent	2	2	1	1

*In case of the sections with scattered irrigation, the number of posts will vary depending upon the number of irrigation tanks.

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Annex III

Operation and Maintenance Cost, Total Water Charges and Annual Receipts of the Average Irrigation Systems

(Rs. in lakhs)

Particulars									
	1981-82	1982-83	1983-84	1981-82	1982-83	1983-84	1981-82	1982-83	1983-84
A. Annual operation and maintenance cost									
1. Staff salaries	30.67	35.39	42.75	3.05	3.86	4.63	0.14	0.16	0.17
2. Recurring non-salary cost	26.18	29.17	30.28	2.63	2.71	3.17	0.10	0.12	0.12
Total cost	56.85	64.56	73.03	5.68	6.57	7.80	0.24	0.28	0.29
B. Total water charges and collection									
1. Total water charges	98.65	94.69	96.66	5.69	7.30	7.49	0.33	0.36	0.33
2. Collection of water charges	46.36	58.74	64.88	2.89	4.45	4.83	0.22	0.17	0.19
3. Overdues of water charges	52.29	35.95	31.78	1.80	2.85	2.56	0.11	0.19	0.14
C. Annual receipts									
1. Collection of water charges	46.36	58.74	64.88	2.89	4.45	4.83	0.22	0.17	0.19
2. Overdues of previous year	8.12	3.25	6.45	2.08	1.23	2.33	0.06	0.02	0.06
3. Penalty receipts	3.06	0.60	1.46	0.02	0.01	0.01	-	-	-
4. House rent and other recipts	1.09	2.08	2.30	0.40	0.51	0.32	-	-	-
Total receipts	56.63	64.70	75.09	6.09	6.20	7.49	0.28	0.19	0.25

WMS Reports

WATER MANAGEMENT SYNTHESIS PROJECT REPORTS

WMS 1 Irrigation Projects Document Review

Executive Summary
Appendix A: The Indian Subcontinent
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WMS 3 Bangladesh/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 4 Pakistan/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 5 Thailand/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 6 India/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 7 General Asian Overview

WMS 8 Command Area Development Authorities for Improved Water Management

WMS 9 Senegal/USAID: Project Review for Bakel Small Irrigated Perimeters Project No. 685-0208

WMS 10 Sri Lanka/USAID: Evaluation Review of the Water Management Project No. 383-0057

WMS 11 Sri Lanka/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 12 Ecuador/USAID: Irrigation Sector Review

WMS 13 Maintenance Plan for the Lam Nam Oon Irrigation System in Northeast Thailand

WMS 14 Peru/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 15 Diagnostic Analysis of Five Deep Tubewell Irrigation Systems in Joydebpur, Bangladesh

WMS 16 System H of the Mahaweli Development Project, Sri Lanka: 1980 Diagnostic Analysis

WMS 17 Diagnostic Analysis of Farm Irrigation Sysems on the Gambhiri Irrigation Project, Rajasthan, India: Volumes I-V

WMS 18 Diagnostic Analysis of Farm Irrigation in the Mahi-Kadana Irrigation Project, Gujarat, India

WMS 19 The Rajangana Irrigation Scheme, Sri Lanka: 1982 Diagnostic Analysis

WMS 20 System H of the Mahaweli Development Project, Sri Lanka: 1983 Diagnostic Analysis

WMS 21 Haiti/USAID: Evaluation of the Irrigation Component of the Integrated Agricultural Development Project No. 521-0078

WMS 22 Synthesis of Lessons Learned for Rapid Appraisal of Irrigation Strategies

WMS 23 Tanzania/USAID: Rapid Mini Appraisal of Irrigation Development Options and Investment Strategies

WMS 24 Tanzania/USAID: Assessment of Rift Valley Pilot Rice Project and Recommendations for Follow-On Activities

WMS 25 Interdisciplinary Diagnostic Analysis of a Work Plan for the Dahod Tank Irrigation Project, Madhya Pradesh, India

WMS 26 Prospects for Small-Scale Irrigation Development in the Sahel

WMS 27 Improving Policies and Programs for the Development of Small-Scale Irrigation Systems

WMS 28 Selected Alternatives for Irrigated Agricultural Development in Azua Valley, Dominican Republic

WMS 29 Evaluation of Project No. 519-0184 USAID/El Salvador, Office of Small-Scale Irrigation - Small Farm Irrigation Systems Project

WMS 30 Review of Irrigation Facilities, Operation and Maintenance for Jordan Valley Authority

WMS 31 Training Consultancy Report: Irrigation Management and Training Program

WMS 32 Small-Scale Development: Indonesia/USAID

WMS 33 Irrigation Systems Management Project Design Report: Sri Lanka

WMS 34 Community Participation and Local Organization for Small-Scale Irrigation

WMS 35 Irrigation Sector Strategy Review: USAID/India; with Appendices, Volumes I and II (3 volumes)

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WMS 36 Irrigation Sector Assessment: USAID/Haiti

WMS 37 African Irrigation Overview: Summary; Main Report; An Annotated Bibliography (3 volumes)