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Capital Costs of Major and Medium Irrigation Schemes in India

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Foreword

Irrigation has been a major contributing factor in the Green Revolution experienced by India during the late 1960s and the 1970s. While the considerable achievements of the irrigation sector have been appreciated by all, there has been very little attempt at estimating the cost at which this achievement has taken place. The estimates of cost generated so far by various Government groups and agencies suffer from serious limitations in terms of methodology and have resulted in gross under-estimation of real costs of investments in this sector. The present paper attempts to estimate the cost incurred in the development of surface irrigation schemes - both at the aggregate and at the project-specific level, keeping in mind all the complexities involved in such estimation, in order to assess the broad range within which the estimates would fall. In order to arrive at this estimate, the study takes into account the two salient factors: (i) inflation rate and (ii) gestation lag, i.e., the lag that exists between the time investment is undertaken and irrigation potential created, which have hitherto been ignored by official estimates.

The results of the study show that capital cost per hectare of irrigation development taking place, has been the highest in the eighties decade. The exercise also indicates that the states of the Southern region have incurred the highest cost, while those of the Northern region display the least per hectare cost. Cost of development has also been evaluated in relation to size of the projects and the gestation lags inherent in each.

The present paper forms a part of the collaborative project entitled "Irrigation Cost and Cost Recovery in India", between International Food Policy Research Institute (IFPRI), Washington D.C. and National Council of Applied Economic Research (NCAER), New Delhi.

I hope this paper would be of immense use to irrigation engineers, planners, policy makers and academicians having interest in water related issues of this country.

April, 1994

S. L. Rao
Director General

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Glossary of Terms

CWC	:	Central Water Commission
GOI	:	Government of India
Ha	:	Hectare
HYV	:	High Yielding Variety
K(CPC)	:	Cost of Cumulative Potential Created
K(CPU)	:	Cost of Cumulative Potential Utilized
K(PU)	:	Cost of Incremental Potential Utilized
PC	:	Potential Created
PTP	:	Pure Time Preference
PU	:	Potential Utilized
TE	:	Triennium Ending
UIP	:	Ultimate Irrigation Potential
UT	:	Union Territory

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Capital Costs of Major and Medium Irrigation Schemes in India

1. Introduction

The success of the green revolution in India during the late 1960s and its rapid spread during the 1970s is attributed, to a large extent, to the irrigation network that existed in the northwest of India. Canals in the initial stages, and tubewells immediately thereafter, along with HYV seeds and chemical fertilizer, became the main catalysts of growth in Indian agriculture. A number of studies have highlighted the role of irrigation in enhancing India's foodgrain production,[1] but the cost at which this has been achieved remains much less explored.

In addition to the historical interest this question holds, the costs of surface irrigation development, their regional differences, and their trends over time are important considerations in the ongoing debate over intersectoral investment priorities and the numerous intrasectoral investment choices faced during the development of each new five-year plan. One area of considerable recent controversy centers on the cost of major and medium irrigation development vis-a-vis minor (groundwater) irrigation development[2]. This debate is ill-informed and inconclusive at present, in part because of the inadequacy of existing estimates of the capital costs of irrigation schemes[3]. The controversy, however, has brought into focus the complexities involved in properly estimating the costs of irrigation.

The most common approach to reporting irrigation development costs has been that employed by the Planning Commission, which simply divides the expenditure incurred on major and medium irrigation schemes during a plan period by the potential created during that same period. During the last forty years (1951-90), the nation has spent Rs 262.22 billion (in absolute terms) on major and medium irrigation schemes. Over this same period, irrigation potential increased by 22.14 million hectares (Government of India, 1989).[4] During the first 15 years of planned development (1951-65), potential increased, on average, 457,000 hectares per annum. During the next 8 years (1966-74), the pace increased to 517,000 hectares per year, accelerating further to 983,000 hectares per year during 1974-80. During the 1980s the rate of expansion declined again to 524,000 hectares per annum (1980-90). (Table 1).

Using these data and employing the simple plan-wise approach, the Working Group on Major and Medium Irrigation Program for the Eighth Plan (Government of India, 1989) calculates apparent investment per irrigated hectare at Rs 1,530/hectare for the First Plan. This amount gradually rises to Rs 34,924 for the Sixth Plan and is expected to touch Rs 36,240 in the Seventh Plan, a rise of more than 23 times the earlier value. (Table 1).

These estimates obviously are non-comparable because of two serious limitations: (1) they are reported at current prices prevailing during the various plan periods, unadjusted for inflation, and (2) there exists a gestation lag between the time investment is undertaken and the time irrigation potential is created, which is neglected in the estimates. The technique for adjusting current prices to constant ones is straightforward, though not necessarily simple, and it is surprising that it is so seldom employed in discussions of Indian irrigation costs. The gestation lag issue is more complex and has come to the fore only recently.

Svendsen (1991) made a crude attempt to adjust Planning Commission expenditure estimates for inflation effects in a 1988 workshop paper, using the domestic price deflator for industry applied to the middle year of each plan period to put expenditure estimates on a common 1980 footing. Results indicated that by the time of the Seventh Plan, costs had risen only to about 2.3 times those of the First Plan, rather than the 23 fold increase implied by the nominal figures. The Eighth Plan working group went through a similar exercise with the results shown in Table 1.

To address the second issue raised above, a two-part question must be asked. First, what is the gestation lag in major and medium irrigation schemes between the time investment is undertaken and the time potential is created, and, second, what is the value that society attaches to "Pure Time Preference" (PTP), i.e., the rate at which society would discount future or compound past benefits? The first part of the question is important by itself because, since the construction of an irrigation project sometimes takes more than one, or even two, five-year plan periods to complete[5], expenditures shown for a particular plan period do not necessarily correspond to the potential created as a result of that expenditure. If the investment level is relatively constant from year to year, this difference does not matter a great deal. When the level of investment is growing, however, as it generally was in India during this period, a simple plan-wise computation will overestimate the cost of a hectare of potential created. At the 1988 IFPRI-sponsored workshop, Svendsen (1991) pointed out this problem and used unpublished Planning Commission data to estimate the cost of creating a hectare of irrigation in various plan periods, adjusting for both inflation effects and for the pure gestation lag effect. This approach resulted in estimates of per hectare investment which were lower than the inflation-adjusted figures mentioned above by a factor of 2. It also indicated that irrigation development cost has increased by a factor of about 1.8 over the 40 year period.

There is a second aspect to the gestation lag problem, however, that has not yet been addressed, and this part of the question is somewhat more involved. Since a rupee invested in period t_0 and one invested in t_1 have different values due to the existence of PTP, this lag factor remains crucial even when the investments are viewed at constant prices and where real investment levels from one period to the next are constant. The importance of this gestation lag has been recognized (Mitra, 1990) but heretofore no attempt has been made to include it in the estimation of the capital cost of irrigation in India. This study attempts to estimate the impact of this effect and to refine previous estimates by incorporating all three of the factors cited above into capital cost estimates.

The three factors work in opposing directions, and the resultant unit cost may go up or down, relative to simple plan-wise estimates, depending upon (a) the rate at which the investment plan accelerates, (b) the exact value of the gestation lag, and (c) the value of social rate of compounding applied to past expenditures. While factor (a) would tend to lower unit cost estimates, factors (b) and (c) would jointly push them upwards. The final result rests on the relative values of the two sets of factors, i.e., the rate at which investment plan accelerates and the rate at which past expenditures compound.

The practical complexities involved in resolving these issues are many, and the present study is felt to be a reasonable compromise between precision and practicality. Specifically, it proposes to estimate the capital cost of major and medium irrigation schemes in India per hectare of potential created and potential utilized, employing two different methodological approaches–one at an aggregate level for different states and the nation as a whole, and the other analyzing project-specific data for selected states.

In what follows, each of these approaches is discussed in greater detail and then employed to try to obtain reasonable estimates of irrigation development costs and the changes which have occurred over the past 40 years. In Section 2 the methodological framework employed to deal with (a) aggregate data at state and all India levels, and (b) project-specific data is spelled out. Based on this methodological framework, estimates of capital cost using both methodologies are derived for different regions in Section 3, the results compared, and some of the implications explored. Section 4 then presents a summary and conclusions.

2. Methodological Framework[6]

Inflation Rate for Capital Outlay on Irrigation

In order to estimate the inflation rate relevant for capital outlay on major and medium irrigation schemes in India over time, one must first know the various components of the capital cost and their relative weights. To estimate these, discussions were held with a number of engineers[7] in the Central Water Commission (CWC), a central government body charged with responsibility to review designs for all major and medium schemes to be built in the country. Based on these discussions, irrigation scheme costs were classified into four broad categories (a) labour and miscellaneous items not included under other heads, (b) cement, (c) iron and steel, and (d) machinery and transport equipment. Their respective weights were judged to be 0.60, 0.20, 0.15 and 0.05.

The inflation rate for labour and other miscellaneous cost items is rather difficult to estimate due to sizeable heterogeneity, not only of skills within the labour component, but also within other miscellaneous items. In the absence of information on proportions of various kinds of labour employed in constructing projects, data on agricultural wages have been used to estimate the inflation rate of labour and other miscellaneous cost items[8]. Obviously, this presumes that the wage component of the unskilled workers in the total labour cost is dominant and that it increases at the same rate at which other cost items of this component increase. This exercise yielded an overall annual inflation rate for this cost category of 7.88 percent.

To estimate inflation rates for categories b, c, and d, the Economic Adviser's wholesale price index series for cement; iron, steel and ferro alloys; and machinery and transport equipment were used to estimate their respective inflation rates for the period 1950-51 to 1988-89. Annual rates of increase turned out to be 6.94 percent for cement, 8.41 percent for iron, steel and ferro alloys, and 6.07 percent for machinery and transport equipment.

However, the temporal behaviour of all of these prices exhibits significant differences over four decades. Consequently, decadal inflation rates were derived for all four cost categories (Table 2) and used to convert year-wise irrigation expenditures to constant 1988-89 prices. To these decadal rates were attached their respective weights of 0.60, 0.20, 0.15 and 0.05 to obtain an overall weighted inflation rate for capital outlay on major and medium irrigation schemes in India. This annual rate comes out to 3.018 in the first decade (1950-59), 6.266 in the second decade (1960-69), 8.538 in the third decade (1970-79) and 11.127 in the fourth decade (1980-88). The rate of inflation of irrigation cost for the entire period under consideration works out to 7.66 percent per annum (Table 2). The above estimated rates of inflation for capital outlay on major and medium irrigation schemes were used to convert actual (book value) expenditures for each state, shown in Table 3, to 1988-89 price levels. For aggregative state-level estimation it was assumed that real expenditures are uniformly distributed over the years of the plan[9].

Thus, annual expenditures so derived, and actual annual expenses in the case of project-specific analysis, incurred during 1951-52 to 1959-60 were converted to 1988-89 price levels by using four decadal inflation rates (D1, D2, D3, and D4). Similarly three rates of inflation (D2, D3, and D4) were used to convert expenditure incurred during 1960-61 to 1969-70; two inflation rates (D3 and D4) for expenditures incurred during 1970-71 to 1979-80; and one inflation rate (D4) for expenditures of 1980-81 to 1989-90.

Table 3 also contains data on Potential Created (PC) and Potential Utilized (PU). Potential created is the area actually supplied with water delivery facilities. Potential utilized is the area which is typically supplied with irrigation water for at least one season. Since the beginning of national planning in 1950 there has been a gap between these two values, and this gap has been widening since the mid-1970s, a matter of considerable official concern. In this study, specific costs of irrigation development will be expressed in terms both of rupees per hectare of PC and rupees per hectare of PU.

The Gestation Lag

Duration

The second important issue relates to the gestation lag between expenditure incurred and potential created through major and medium irrigation schemes. Major irrigation works, particularly mega-projects having irrigation potential of more than 100,000 hectares, have very long gestation periods, which may exceed two decades. Medium schemes generally can be completed within five to seven years. Within size categories, however, gestation periods differ widely from project to project, influenced by factors ranging from availability of finance to technical difficulties.

In addition, projects neither incur their total expenditure in a given year, nor do they produce their benefits (irrigated area) at one time. While expenditure spreads over a number of years, so does the creation of irrigation potential. Neither follows any fixed pattern[10]. Further, the gestation lag itself may vary over time. As a result, computing a time lag for a project—much less a group of projects—is not as straightforward as it might appear. To address this complex gestation lag problem, a project specific analysis was also carried out.

To carry out the state level aggregative estimation, it was necessary to find an average estimated gestation lag which could be applied to the entire portfolio of projects in a given state. Irrigation engineers interviewed at the CWC agreed that the gestation lag in major projects would typically be on the order of 10 to 12 years where timely funding was available, extending up to 20 years where funding or other constraints were severe. The engineers interviewed felt that medium projects could generally be expected to be completed within 5 to 7 years. The average estimated gestation lag employed must be selected to apply to a typical mix of major and medium projects under normal conditions (neither very efficient nor very inefficient). Accordingly, a fixed gestation period of 12 years between the time investment is undertaken and potential created was assumed[11].

Social Discount Rate

The other important question associated with gestation period is that of social rate of discount or pure time preference, i.e., the value the society attaches to consumption now versus consumption at some time in the future. Theoretically, its value is deemed to equal the rate at which real per capita income of the society grows, multiplied by the elasticity of marginal utility with respect to real per capita income[12]. In symbols, it may be denoted as $r_{pcy}*e_{mu,pcy}$, where r_{pcy} is the rate of growth of real per capita income and $e_{mu,pcy}$ is the elasticity of marginal utility with respect to real per capita income. The product of these two factors ($r_{pcy}*e_{mu,pcy}$) provides the rate of fall in marginal utility as a result of economic growth. In other words, it designates how the marginal satisfaction from income (expenditure) changes as the economy progresses. In India, while real per capita income has increased at about 1.5 percent per year over the last forty years, its rate of growth has been above 2 percent during 1980s. Regarding the elasticity of marginal utility with respect to per capita income, although there are several methodological complexities involved in its estimation, attempts have been made by some scholars who have obtained a value of about 1.75 (Murty, 1982). They are also of the opinion that it will go up to 2.5 or more if one were to include the impact of various policies aimed at reducing income inequalities. In this case, an income growth rate of 2.0 percent, coupled with an elasticity of marginal utility of 2.5 yields a value of 5 percent as social rate of compounding based on this analytical framework.

The Planning Commission of India, however, has traditionally taken 12 percent as the social rate of discount for evaluating various projects, as has the IBRD. This gives us some sort of an upper limit. Since the objective here is not to estimate precisely the social rate of compounding, which is influenced by a host of factors, but rather to estimate the capital cost of major and medium irrigation system construction under realistic assumptions, the aggregate analysis has been conducted at three alternative social discount rates. The values selected are 5.0 percent, 7.5 percent and 10.0 percent. The aggregate analysis thus applies these three rates respectively with a time lag of 12 years to expenditures incurred in different plan periods figured at 1988-89 prices. In the project-specific analysis, a single rate of 5 percent has been utilized to estimate capital cost.

Computational Methods

Aggregate Analysis

In the aggregate analysis, estimates of capital costs of irrigation development have been derived both at the regional level and at an all India level. Further, all India estimates have been derived separately for irrigation potential created, K(PC), and potential utilized, K(PU). Each member of this pair of all India estimates has three alternative values attached to it, each associated with a different rate of social discount. Thus K1(PC) and K1(PU) correspond to 5 percent compounding; K2(PC) and K2(PU) to a 7.5 percent rate, and K3(PC) and K3(PU) to a 10 percent rate of compounding. For example, K1(PC) for the year 1963-64 has been derived by dividing the expenditure incurred in 1951-52 (obtained from Table 3, converted to 1988-89 prices, and adjusted for a social rate of compounding of 5 percent for 12 years using coefficients from Table 4) by the irrigation potential reported to have been created during the year 1963-64 (also from Table 3). All these estimates, therefore, are at 1988-89 prices and take the gestation lag into account. To iron out abrupt year to year changes in these estimates, three-yearly moving averages are calculated. Thus, the estimate shown against 1964-65 is, in fact, an average of 1963-64 to 1965-66[13].

Project-Specific Analysis

The estimates for the capital cost of irrigation development through project-specific analysis have been derived in a somewhat different manner. Because expenditures incurred during initial years lay the base for potential creation in subsequent years, the inflation-adjusted value of the expenditure stream must be allocated appropriately over those years when potential is created. It is then necessary to discount expenditures, accounting for PTP, to arrive at the true capital cost. This is attempted in the following manner.

First, all actual expenditures are converted to 1988-89 constant prices using the appropriate combination of decadal inflation factors. As indicated above, it is assumed that expenditures incurred during the initial lag years act as a base for all future potential creation. But even after potential creation for the project begins, annual expenditures do not create that year's potential alone. Rather they too form a base for the creation of irrigation potential from the scheme in all subsequent years. Therefore, each year's expenditure, at 1988-89 constant prices, is allocated to all succeeding years of the concerned project in the ratio of its created potential to total cumulated potential of the remaining years. At this stage, the concept of PTP is brought in. Thus, that part of each year's expenditure which is allocated to subsequent years (in the ratios explained above) is compounded at a rate of 5 percent per annum to account for PTP, up to the year when relevant potential is created. Thus, to bring the expenditure at constant prices (base year 1988-89 = 100) of say year i to the level of year j when the relevant potential is created, it is necessary to use a social rate of compounding (in this case 5 percent) over period j-i. Hence, in year j, expenditure at constant prices e_i of year i will become $e_i(1+0.05)^{j-i}$. This two stage process takes care of the inflation factor as well as the PTP inherent in the actual structure of gestation lag in each project.[14]

For estimating capital cost per hectare of incremental potential created or utilized, the allocated expenditure of each year is divided by the incremental potential created, pc_i, or utilized, pu_i, in that year, while for estimating capital cost per hectare of *cumulative* potential created or utilized, the *cumulative* allocated expenditure against a particular year is divided by the *cumulative* potential created or utilized up to that year (cpc_i)[15]. In this manner both the lag factor and the inflation rate have been taken into account in the estimate of capital cost [K(CPC) or K(PC)] of irrigation development.

For the sake of comparison, three different sets of cost figures have been estimated. Cost C1 is the accountant's cost, which is merely the sum total of expenditures at historical prices divided by the cumulative potential created by the project under consideration. For cost C2, all expenditure incurred in a particular project has been converted to 1988-89 prices using decadal inflation rates and then divided by the total potential created by the project. However, PTP is still being ignored in these estimates, which leads to the final set of estimates of capital cost of potential creation, K(CPC), and utilization, K(CPU).

It must be kept in mind that the K(PC) estimates developed through the aggregate exercise represent the cost of *incremental* potential creation, whereas in the project-specific study it is the cost of *cumulative* potential creation K(CPC) which has been estimated. In undertaking the aggregative exercise, interest was in seeing how cost of potential creation varied over time. In the project-specific analysis, study of the time profile of development cost of incremental potential was found to be difficult, because, for a given year, costs fluctuated a great deal. To eliminate these fluctuations, focus was shifted to the cost of cumulative potential created, concentrating on the cost incurred by individual projects at the end of the project or at the end of the period under study.

3. Estimates of Capital Cost

Aggregate Analysis

Behaviour Over Time

Tables 4 and 5 present year-specific estimates of capital cost on a per hectare basis for major and medium irrigation schemes over the period 1963-64 to 1994-95. Estimates are presented for all India (Table 4) and for specific regions (Table 5). These estimates reveal an interesting pattern. For example, at all India level, the temporal behaviour of cost is U-shaped with lower left arm (Figure 1). It decreases quite rapidly over the first 11-year period (1964-65 to 1975-76), remains relatively constant for the next three years, then rises steeply up to 1988-89, and finally shows some decline over the next five years. A perusal of Table 4 and Figure 1 reveals clearly that the capital cost of irrigation through major and medium schemes was the lowest for the irrigation potential created during the Fifth Plan period (1974-78) and the highest during the Seventh Plan (1985-90). The onset of 1980s saw an acceleration in cost as potential creation slowed down. As noted earlier, potential creation dropped from 983,000 hectares per annum during 1974-80 to only 524,000 hectares (per annum) during 1980-90.

This U-shaped behaviour is present whether one considers capital cost with respect to potential creation (PC) or potential utilized (PU). K1(PC) (5 percent rate of compounding) generally provides the lower bound of various cost estimates, while K3(PU) (10 percent rate of compounding) gives the upper limit. The difference between the lower and the upper bounds is more than 100 percent. For example, K1(PC) for the entire period from 1963-95 works out to Rs 35,085 while K3(PU) turns out to be Rs 73,485. The range between K1(PC) and K3(PC), where both are based on potential created, is somewhat lower (about 75 percent).

All India: Trends in Capital Cost
(Major & Medium Irrigation Schemes)

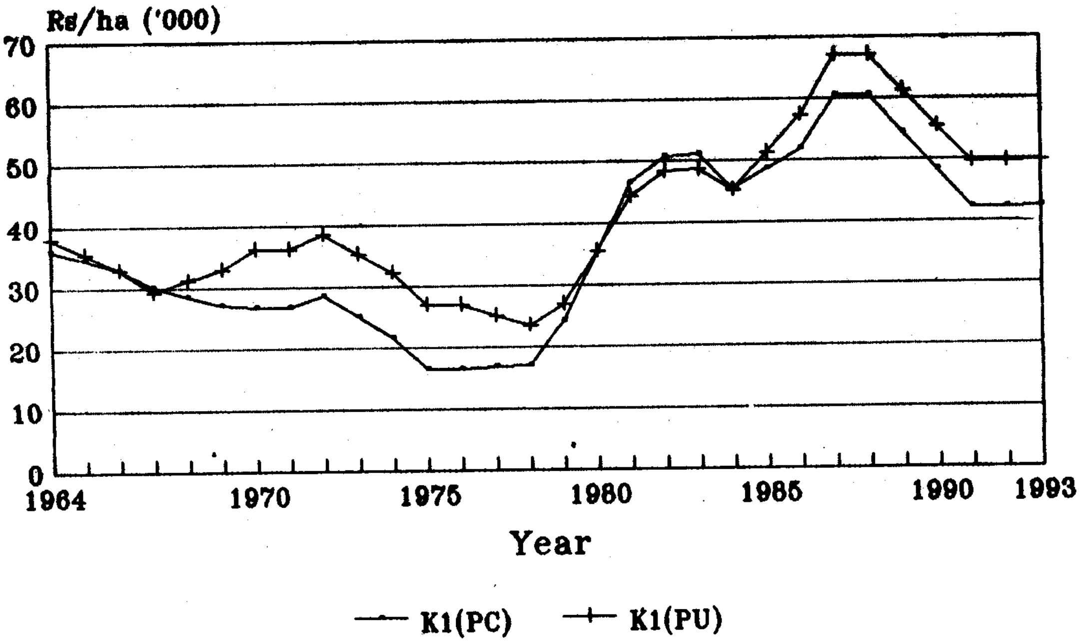

Figure 1

Source: Gulati, et.al 1994

Although in any particular year K(PC) is normally lower than K(PU), K1 and K3 of either PC or PU generally bear roughly the same relationship to one another. The average estimate of K1(PC) over the entire decade of 1980s works out to Rs 50,508 and that of K3(PU) as Rs 91,959 at 1988-89 prices, giving a range of about 82 percent. It may be interesting to note here that these estimates of capital cost are higher than those prevailing in either pre-1980 period or those likely to prevail during the Eighth Plan (1990-95). In particular, the estimates of capital cost of irrigation potential created during 1980s are more than two and a half times the corresponding estimates of irrigation potential created during 1974-80.

Comparison with CWC Estimates

It is interesting to compare the estimates obtained in this study with those which are given by the Central Water Commission (CWC). The CWC calculates the capital cost of irrigation development through major and medium schemes by simply dividing the expenditure incurred in a particular plan with irrigation potential created during the same plan, following the pattern described in Section 1. It neither adjusts for inflation nor for gestation lag. Further, for a particular five year plan CWC estimates of irrigation cost remain unidentified with any specific year's price level. If one takes a plan estimate to be at the middle year's price level and compares it with our estimates, which are at 1988-89 prices, the two sets of estimates would diverge widely. But the CWC estimate for the Seventh Plan, which is likely to be at 1987-88 price level (the middle year of the Plan), may be comparable to our estimate. Our lowest estimate of K(PC) is Rs 55,180 per hectare, which is 52 percent higher than the corresponding estimate of Rs 36,240 given by the CWC. Even if one allows for one year's inflation because our estimate is at 1988-89 prices, our estimate still remains substantially above that of the CWC. Our alternative estimates corresponding to 7.5 and 10 percent social rates of compounding (on a potential created basis) turn out to be 102 and 166 percent higher, respectively, than the CWC estimate. Thus, it appears that CWC estimates, at least for the 1980s, understate the actual cost of irrigation development through major and medium schemes by 50 percent or more. Such a result also implies that a proper valuation of expenditures, through adjustments for inflation and social rate of compounding, increases cost more than the size effect of an expanding portfolio tends to reduce apparent cost.

Regional Variations

We have also estimated the capital cost of irrigation development for different regions of India. For this purpose, the major states of India have been grouped into five regions: (i) Northern Region comprising of Punjab, Haryana and Uttar Pradesh; (ii) Eastern Region comprising of Bihar, Orissa, West Bengal and Assam; (iii) Southern Region that comprises of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala; (iv) Western Region comprising of Rajasthan, Gujarat, Maharashtra and Madhya Pradesh; and (v) Hill Region that comprises of Himachal Pradesh and Jammu & Kashmir. Looking at these regions from the point of view of topography, one finds that much of the Deccan Plateau falls in the Western and Southern regions. The lands are rather undulating which is expected to increase the cost of constructing canal networks. Moreover, these regions do not benefit from the flow of the large snow-fed rivers which characterize the Indo-Gangetic Plain. Thus, *a priori*, one expects the cost of irrigation development to be higher in the Western and Southern Regions than in the Northern and Eastern Regions. The Hill Region may be kept in the background due to its very low irrigation potential.

Our estimates of capital cost of irrigation development through major and medium schemes for the four main regions of India reveal that, on an average, for the period 1963-95, the Southern Region has the highest cost per hectare of irrigation potential created [K1(PC) = Rs 55,199], followed by Western (Rs 39,211), Eastern (Rs 29,440) and Northern (Rs 22,426) regions in that order (Table 5). This ranking broadly confirms higher costs in the Southern and Western Regions than in the Eastern and Northern Regions. The cost in the Southern Region is almost two and a half times the cost in the Northern Region.

During the 1980s, however, this pattern of ranking becomes distorted. For example, K1(PC) of the Southern Region (Rs 61,375) is followed by Eastern Region (Rs 56,672), Northern Region (Rs 52,062), and Western Region (Rs 50,966). This somewhat unusual behaviour of cost in 1980s results from a dramatic fall in the potential created in the Northern Region, particularly during the first five years of the 1980s. Irrigation potential created in this region declined from 388 thousand hectares (per annum) during 1974-80 to just 61.6 thousand hectares (per annum) during 1980-85. Although other regions also experienced falls in the potential created during the Sixth Plan compared to 1974-80 period, the magnitude of their falls was nowhere near that of the Northern Region. The net result of this was a sharp rise in the capital cost of irrigation of this region, which shot up so high that it exceeded even that of the Western Region.

Efforts to probe more deeply into the reasons for this drastic decline in the irrigation potential created revealed that in Uttar Pradesh, for certain very big projects, the estimates of potential created were in fact revised downwards, as it was realized that there had previously been significant over-reporting of potential created for these projects. This adjustment of over-reporting in Punjab turned the estimates of irrigation potential negative during the Sixth Plan (Table 3). Ignoring these oddities of the Sixth Plan, if one views the entire period from 1963-64 to 1994-95, the estimates of capital cost of irrigation development for the Southern and Western Regions remain higher than the all India estimates, while those of the Eastern and Northern Regions fall below it[16].

Project Specific Analysis

As noted before, estimates of capital cost derived on the basis of project-specific analysis can provide more accurate estimates of gestation lag of projects. However, these estimates have their own shortcomings, the most important of which is that, because some project records are incomplete, it no longer remains possible to include in the analysis every project taken up in a particular state since independence. This reduces coverage of projects, and may reduce the accuracy of the final cost estimate obtained using a weighted average of project-specific costs. The coverage achieved varies from state to state depending on the availability of data. For this exercise, project-specific analysis has been carried out for 10 states — Uttar Pradesh, Haryana, Punjab, Bihar, Orissa, Karnataka, Tamil Nadu, Gujarat, Madhya Pradesh, and Rajasthan.

Three hundred and forty-seven projects, initiated during the plan period and spread over the 10 states, were ultimately submitted for detailed cost-analysis. Their distribution by state and region is shown in Table 6. Expenditure data was available for another 215 projects which could not be included in the analysis as they had created no irrigation potential by the end of the VII Plan, either because they were stabilization projects which do not directly yield additional irrigated area, or because, though incurring expenditure, they had not yet started yielding benefits.

Behaviour Over Time

The average cost of potential creation for the country as a whole, based on the data from these 10 states, is Rs 27,056/ha, in 1988-89 prices, when the potential created by the projects in the study are taken as weights. The weighted average cost of cumulative potential creation is a little higher, Rs 28,988/ha, when weights used are the total potentials created by all the projects in a particular state.

As in the aggregative exercise, the time profile of cost for the states included in the project-specific exercise shows that the highest average cost has been during the decade of the eighties, and that this cost of cumulative potential creation has been rising throughout the 1980s. The time profile of costs for the 1950s and 1960s was less meaningful because there are only a handful of projects for which reasonably complete expenditure and potential creation records exist for those two decades.

Regional Variations

The results of the project-specific exercise show the same rank ordering of regional cost of cumulative potential creation as does the aggregative exercise. As in the aggregate results, the highest regional cost is found to be in the South, where the weighted average of Karnataka and Tamil Nadu is Rs 49,118 per hectare of cumulative irrigation potential created (Table 7). The South is followed by the Western Region, where the weighted average per hectare cost is Rs 34,436. The Eastern Region displays the next highest cost at Rs 26,424 per hectare. The lowest cost, as in the aggregative exercise, is for the Northern Region, where the weighted average cost of cumulative potential creation is only Rs 15,586 per hectare.

Project Size and Project Cost

An interesting hypothesis to examine at a project-specific level is the relationship between size of project and its cost per hectare. We hypothesize that this size-cost relation is inverse in nature, i.e., large projects have lower per hectare costs. This hypothesis rests on the principle of scale economies which are assumed to reduce construction costs of the larger projects. To empirically examine the hypothesized inverse relationship, we have looked at the aggregate picture of the 10 states taken together and also examined the state results individually.

One problem encountered was ambiguity in the classification of Major and Medium irrigation schemes. Until the end of the IV Plan (1973-74), the distinction between Major and Medium irrigation schemes was based on expenditure incurred. From the V Plan onwards, however, the distinction was based on the ultimate irrigation potential (UIP) each project is expected to create. Projects with UIP of less than 2,000 hectares are classified as Minor, those with UIP between 2,000 and 10,000 hectares are classified as Medium, and projects with UIP greater than 10,000 hectares are designated Major. To deal with this problem, all projects included in the study were assigned to a category on the basis of their size, as measured by the number of hectares of irrigation potential created or utilized by them, regardless of the class to which they may have been originally assigned.

Of the 347 projects, 94 belonged to the category of Minor surface irrigation schemes, 131 were Medium schemes, and 122 were Major. Collectively, the Minor, Medium, and Major surface irrigation schemes have created approximately 120,000, 600,000 and 10,500,000 hectares of irrigation potential, respectively. Within the share of Major schemes, about 7.6 million hectares of potential has been created by mega projects, i.e., schemes with a size greater than 100,000 hectares (Table 8).

Here, we must make clear that while discussing the cost per hectare of potential created (PC) or potential utilised (PU), we are talking about 2 different sets of data, specifically with regard to examining the hypothesis of inverse relation between size and cost. While looking at the cost per ha of PC, we have classified the projects on the basis of potential created by them, while these same projects have been *reclassified* on the basis of potential utilised, when discussing the cost per ha of PU. Thus, a project which has created potential of, say, 12 th.ha falls in the category of Major projects when calculating the weighted average of this category; while the same project, if it has utilised an irrigation potential of 7 th.ha, will be considered in the Medium projects category when calculating the weighted average of this particular category.*

In terms of utilized potential, the Minor surface schemes are seen to utilize a potential of 125,000 hectares, about 1.6 percent of the total for

* Thus, strictly speaking, it would not be correct to compare the cost measures based on PC and PU while examining the hypothesis of inverse size-cost relation. Instead, each of these two measures should be considered separately and the inverse relation inspected between the various categories within each measure.

the projects studied, while the Medium projects utilized a potential of 495,000 hectares, approximately 6 percent of the total. For Major projects, the potential utilized totalled 7,319,000 hectares, or 92 percent of the total. Of the Major project share, 5,609,000 hectares, or more than two-thirds of the total, are under the command of mega projects (Table 8).

The aggregate picture presented by the 10 states shows that Minor surface schemes display the highest cost – Rs 83,671 per hectare on the basis of potential created and Rs 189,376 per hectare on the basis of potential utilized. Medium projects show the next highest level of cost — Rs 70,668 per hectare on a potential created basis and Rs 70,227 per hectare on a potential utilized basis (Table 8). Major projects have the lowest cost — Rs 24,141 per hectare on a potential created basis and Rs 34,105 per hectare on a potential utilized basis. These figures support the hypothesis that Major projects entail lower costs per hectare than either Minor or Medium surface irrigation schemes.

On a state-wise basis, in 8 of the states analyzed (excluding Haryana and Punjab), Major irrigation schemes entail lower cost per hectare of cumulative potential created than the Medium surface irrigation schemes. The differences range from 8 to 46 per cent, the highest being in the case of Rajasthan (Table 9). This inverse relation between the size and cost of a project is somewhat contrary to the general impression that major schemes are costlier compared to the medium or small surface irrigation schemes, which appears to be true only in absolute and not in per hectare terms.

Since the share of Major projects in total potential created/utilized is overwhelmingly dominant, this category has been further subdivided into 3 sub-groups separating out projects creating/utilizing irrigation potential: (a) from 10 to 50 thousand hectares, (b) from 50 to 100 thousand hectares, and (c) above 100 thousand hectares. The mega projects display the lowest cost among all the classes discussed here, with the two measures of unit cost being Rs 21,592 per hectare of potential created and Rs 27,730 per hectare of potential utilized (Table 8).

Within the set of sample projects, while the mega projects have the lowest per hectare cost, they have generated almost 68 per cent of the total potential created. In case of potential utilization, the share of mega projects is somewhat larger at about 71 per cent of the total potential utilized.

Although the majority of the irrigation development that has taken place in our sample has been through Major projects, or to be more specific, mega projects, only 20 of the 347 projects analyzed fall into the mega project category. Even Major projects number only about half the combined number of Medium and Minor surface irrigation schemes. Thus, although small and Medium projects dominate in terms of numbers, they provide only a small fraction of the total surface irrigation command developed since independence[17].

While these results appear to show an inverse relationship between size and cost, this relationship needs to be tested for more projects in other states before it can be accepted as conclusive. It also must be noted that these costs are only *financial* costs, adjusted for inflation and pure time preference to take care of the gestation lag inherent in the projects. They do not capture the various uncompensated externalities, such as population displacement, ecological effects, waterlogging, and salinization, which often result at significant scales, particularly in case of mega projects. Drainage works, which are required eventually for many large-scale projects in drier regions to alleviate waterlogging and salinization problems, especially for projects in the Northern and Western Regions, are a particular and costly case in point. Thus, there are additional costs attached, particularly to mega projects, which have not been accounted for in the preceding analysis.

Gestation Lag and Project Cost

Of the previously neglected factors influencing irrigation project cost, the one with the greatest policy relevance is perhaps the gestation lag. After the surge in new project starts in the V Plan, succeeding plans, up to and including the VIII Plan, have tried to emphasize completion of projects already begun and to restrict new starts. The Planning Commission has been largely successful in enforcing this intention, and the 47 new starts during the VII Plan was the smallest number for a plan since independence (Figure 2).

Gestation lag is a critical determinant of final project cost, both because it is technically inefficient to construct sizeable projects very slowly over many years, and also because Pure Time Preference, discussed earlier, adds substantially, and unproductively, to the overall cost as lag increases. The project-specific data allow us to look at the gestation lag structure of different kinds of projects to understand the relationships between lag and project size, location, and date of initiation.

Major & Medium Irrigation Schemes

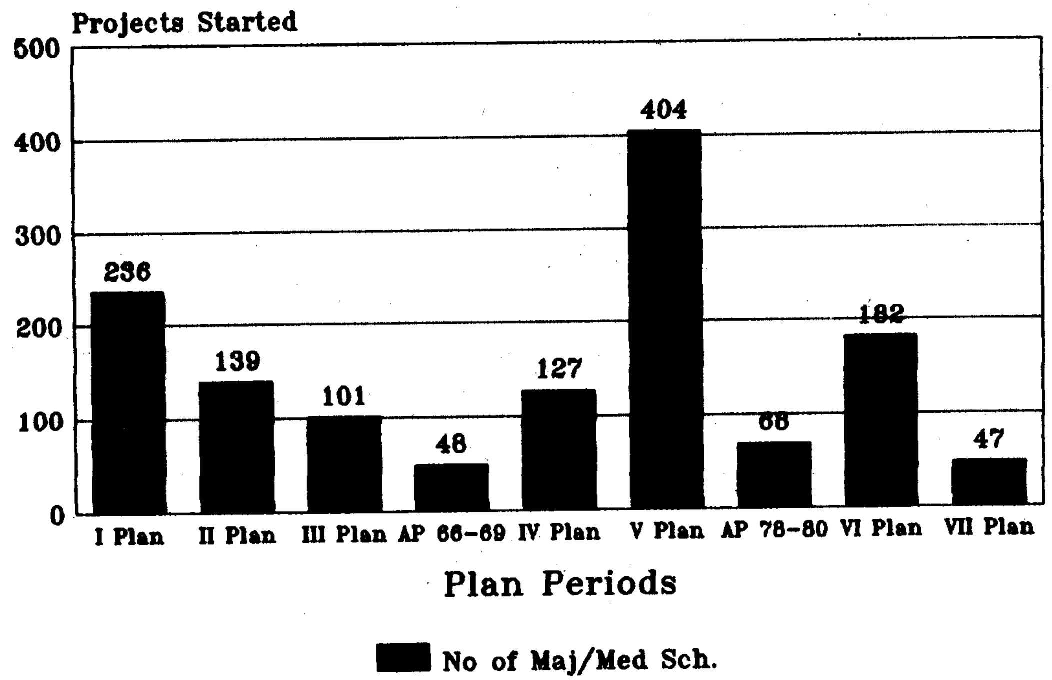

Fig 2

Source: GOI, 1989

Table 10 shows several different measures of lag for Minor, Medium, and Major projects. As seen, pure lag, defined as the time between the date a project is taken up and the creation of the first unit of potential by the project, is approximately 5, 7, and 8 years for the three project types respectively. Weighting each value by size of project within a category makes little difference here, and the differences among the project types are relatively small.

More revealing are the lags shown for the completion of different fractions of UIP. Here weighting makes a significant difference, indicating that, within a category, larger projects, especially large Major projects, take considerably longer to complete than smaller ones in the same category. In addition, a number of projects in the listing have failed to reach 75 percent or 100 percent of UIP, even though funding for them has ceased, and these have been removed from the averages. The estimates shown are thus conservative, particularly for 75 and 100 percent completion lags. Taking the lag to three-quarters completion, relatively sharp differences emerge, with Minor, Medium, and Major projects requiring, on average, 7, 10, and 18 years, respectively, to complete to this stage.

To explore the hypothesis, suggested earlier, that "thin-spreading" of resources in the mid-1970s extended lag periods and raised costs, it is useful to examine lag durations by project start date within size categories. Tables 11A, B, and C show mean pure, 25, 50, and 75 percent lags, weighted by UIP, for Minor, Medium, and Major projects by year of initiation. Several features are of interest. The first is that the projects of all sizes begun during the second half of the 1950s, roughly the II Plan period, show distinctly longer lags than any other period considered. This may reflect the relatively large number of project starts during the I Plan (236), coupled with a scaling up of the state irrigation departments[18]. This same response is seen for both Medium and Major schemes in the early 1970s. After declining from the 1955-59 peak, lags again increase, in a modest way, in the 1970-74 period. This corresponds with the second buildup in new project starts which began with the IV Plan in 1969. Interestingly, however, Medium and Major projects begun during the V Plan, during which the number of new starts skyrocketed to 404, did not show a commensurate increase in completion lags.

One difficulty here is that there is an increasing number of missing values for project area completion toward the end of the period of analysis

(1984). And since some, at least, of these missing values represent uncompleted projects, deleting these cases will exert a downward bias on the estimated average lags. For Medium projects, for example, it is clear from the data that the lag for 25 percent area irrigated has increased from 7.20 years in 1965-1969 to 8.39 years in 1970-1974. However, while the next 5-year period shows a drop in the 25 percent lag, to 8.04 years, values for 5 of the 64 cases are not reported, and hence these cases must be excluded from the average. For 50 and 75 percent completion, the number of missing cases becomes quite large, making these estimates unreliable. The estimate of pure lag for Medium projects, however, shows a small decline for the 1975-1979 period, and a sharp decline to 3.83 years for the final 1980-1984 period,.with no missing values in either case, lending support to the idea that lags are in fact declining in the face of an increasing number of new project starts. Interestingly, the number of new starts during the VI Plan, which corresponds to this last period of substantially shorter lag, was still considerable, ranking third among plans after the V Plan and the I Plan. Major projects also show a decline in lag to first irrigation for 1975-1979, with 1 missing value[19].

This analysis, while far from definitive, casts some doubt on the conventional wisdom that the huge number of V Plan starts resulted in greatly lengthened completion times for Medium and Major projects begun in that period, and is thereby responsible for the sharp increase in per hectare construction costs reported in this study. Some response is evident, as lags did lengthen around the time of the buildup in new project starts in the 1970's, but the pattern does not match well the particular pattern of changes in numbers of new starts occurring then. Moreover, although there are estimation problems caused by incomplete projects in the sample, the magnitude of the increase in completion lags for Medium and Major projects does not seem to be as large as is commonly asserted.

The implication of this finding is that the rapid run up in costs of constructing Medium and Major irrigation schemes evident in late 1970s and early 1980s may include a substantial real increase in actual costs of construction, in addition to higher economic "financing" costs attributed to slower project completion. The picture presented in Figure 1 from the aggregative exercise supports this contention, showing that, while construction costs have fallen back somewhat from their peak of around Rs. 60,000 per hectare in the late 1980s, that decline, assumed attributable to the economic costs of extended construction periods, is less than one-third of the preceding run-up in costs. It is necessary, therefore, to look for other causative factors, including the possibility that new requirements causing previously externalized costs be included within the project are driving project costs upward. In this case, this trend can be expected to continue as concern with environmental impacts, and with oustees, continues to heighten.

Another possibility raised by the scenario sketched above is that, in the 1970s, irrigation departments had excess capacity design and construction capacity which was able to take up the increased workload occasioned by the upturn in new starts. This would suggest, unless reductions in staff levels have taken place in recent years, that with the recent declines in potential creation and new starts, capacity may once again be in oversupply, leading to unnecessarily high establishment costs for irrigation agencies.

Gestation Lag and Region

One clue to the cost advantage of the Northern Region is found in a regional breakout of gestation lags. Table 12 shows lags for all projects by region and by type of project[20]. It can be seen that lags are shortest in all classes for the Northern Region, a major advantage in minimizing system development costs.

Comparison of Estimates

On comparing the results of the two exercises, we find that the two are generally consistent with each other, but there are some differences. The weighted average cost of potential creation for the country as a whole, based on the 10 states taken up under the project-specific exercise, is Rs 28,988/ha when the weights used are the total potential created by all the projects in a particular state. This is about 17 percent lower than the aggregate result of Rs. 35,085. The sign of the difference holds across the regions analyzed, as shown in Table 13. The difference is the largest for the Southern Region at 30 per cent, while for the other regions, the difference between the two estimates ranges between 10 and 12 per cent. The two analyses also produce the same regional rankings.

There are several possible reasons for the consistent differences between the two estimation methods. One is the difference is coverage. In the aggregative regional exercise, states other than those studied under the project-specific exercise were included, though the 10 states selected do cover the largest share of canal irrigation in the country. Moreover, there is no reason to assume the existence of any particular bias introduced by this selection of states. In addition, even for a particular state, not all projects were taken up under the project-specific approach because data for many projects were incomplete, particularly for projects initiated early in the plan period. As indicated earlier, this may introduce a systematic bias in the later plan periods, where projects with missing data may be those which are not yet completed, and thus those with the very longest lags. This tends to make average project-specific estimates lower than they should be, especially for large projects. At the same time, the aggregate estimates may also be underestimating true project cost. As noted in Table 10, the estimated weighted lag to 100 percent completion for major projects, which produce 92 percent of the potential created, is almost 23 years — substantially longer than the assumed 12 year lag. Lengthening the assumed aggregate lag would increase estimated costs across the board.

The time profile of cost under the two different estimation methods both indicate that the highest average cost of cumulative potential creation has been during the decade of the eighties and that this cost has been rising throughout the 1980s. Time profiles of the two estimation methods for the 1950s and 1960s are not so similar, because of the limited data available to the project-specific exercise during those periods.

In any event, the results returned by the two approaches are quite similar, and, in both cases, probably conservative. This gives confidence in the values obtained.

4. Summary and Conclusions

Estimating development cost of Major and Medium irrigation in India is a complex problem. It requires (a) determining the appropriate rate of inflation and, (b) the gestation lag between the time investment is undertaken and potential created and also the social rate of compounding. Estimates usually made of surface irrigation development costs in India do not consider these factors and consequently present a highly distorted picture of the behaviour of irrigation development costs over time. Such estimates, for instance, show irrigation costs rising by a factor of 23 between the first and seventh plans. In fact, real costs have not doubled during this period.

This study employed two complementary approaches to determine the actual costs of Major and Medium irrigation development in India over the past 40 years. One employed aggregate state-wise data on investment and potential creation and utilization and an assumed time lag of 12 years between investment and potential creation. The other traced actual time-dated expenditures for a set of 347 projects drawn from 10 states, combining it with time-dated potential creation data to develop cost estimates for each project. These project-wise estimates are then combined in various ways to obtain average cost estimates. The first approach has the advantage of automatically including all expenditures and all projects in a state. A major drawback is that it uses an assumed time lag, when the actual lag varies by region, year, and size of project. The second approach employs actual time lags, but fails to achieve complete coverage and is biased downward by missing data in later years of project development. Overall, the results from the two exercises are in good agreement.

The results reveal a J-shaped pattern of per hectare capital costs over the period 1963-64 to 1994-95, with minimum cost reached in the late 1970s and the maximum in the late 1980s. The average cost of cumulative irrigation potential created through major and medium schemes over this three decade period is estimated to be about Rs 35,000 per hectare at 1988-89 prices and 5 percent social rate of compounding in the aggregate exercise, and about Rs 29,000 per hectare in the project-specific one. In reality, both of these estimates may underestimate the true cost. The exercise also revealed that, for the 1980s at least, the latest Central Water Commission estimates understate the capital cost of irrigation development by at least 50 percent.

Current costs of irrigation development in India are still about 130 percent higher, in real terms, than those of the late 1970s. Although this study dealt only with costs of surface irrigation development, this raises the question of whether benefits of public canal irrigation have increased to a similar extent, as a result of increased operational efficiency and shifts to higher valued crops. It is likely that a part of the observed increase in per hectare development cost is due to the required absorption of previously externalized costs, such as those borne by the environment, and by uncompensated oustees. This trend will likely continue, driving the cost of canal irrigation development up further.

Across regions, Southern India has the highest cost, followed by Western, Eastern and Northern Regions in that order. The average per hectare costs of cumulative potential created in the four regions, as estimated in the aggregate exercise, are Rs 55,200, Rs 39,200, Rs 29,400 and Rs 22,400 respectively.

For the 347 sample projects, the lion's share of potential created (92 percent) was generated by Major projects, and fully two-thirds of the total came from 20 mega projects having command areas larger than 100,000 hectares. Both analyses showed a robust inverse relationship between size of project and development cost, with Minor projects being the most expensive and Major ones the least expensive. Medium projects, on average, cost about twice as much as Major ones on a per hectare utilized basis. However, the possibility that Major projects generate larger externalities and may experience disproportionately higher cost escalation in the future must be considered. Moreover, these cost estimates do not include the costs of artificial drainage, which is often a future requirement of Medium and Major projects, but is often separated from the cost of original project construction by sunk cost considerations.

Gestation lag is a key determinant of ultimate project costs. Conservative estimates of the lags between project initiation and three-quarters completion are 7, 10, and 18 years for Minor, Medium, and Major projects respectively. The longer the lag, the higher the cost becomes because of compounding. Regionally, lags are shortest in the North, and longest in the East, corresponding to the low and high cost rankings for regions. There is some evidence that lags for Medium and Major projects increased after spurts in new project starts in the early 1950s and the early 1970s. The relationship between lags and number of new project starts is quite imperfect, however, and the magnitude of the lag increase appears to be less that is often suggested. This suggests that the sharp increase in costs during the late 1970s and early 1980s is only partly due to the increase in project durations. Other possible causative factors include additional costs of environmental remediation and oustee rehabilitation, "real" increases due to more difficult site conditions as unexploited irrigation potential diminishes, and higher standards for water control with associated higher costs[21].

Notes

1. In particular see B. D. Dhawan (1988) and the studies referred therein.

2. See B. D. Dhawan's "Major and Minor Irrigation Works: Cost Aspects of the Controversy" and Ramaswamy R. Iyer's "Large Dams: the Right Perspective" in EPW of September 30, 1989; followed by Satyajit K. Singh's article "Evaluating Large Dams in India" in EPW of March 17, 1990; and later by Ashok K. Mitra in the discussion column of EPW of April 21, 1990. This controversy is reproduced in Dhawan's (1990) edited book *Big Dams: Claims, Counterclaims*. It may be worth noting here that Dhawan does not view this controversy as "big versus small" or "major versus minor" due to two main factors. One, there exists a high degree of linkage between these sources of irrigation, and second, that the total requirement of irrigation in India far exceeds the ultimate irrigation potential, indicating that development of full irrigation potential through all sources of irrigation will be necessary to meet growing national needs for food and fiber. Dhawan does venture to provide a hypothesis regarding the relative costs of the two sources of irrigation suggesting that they are in the ratio of 2:3, i.e., the cost of irrigation through major and medium irrigation works would be lower than that through minor (ground water) schemes by about 33 per cent. Ramaswamy, addressing only on the capital cost of irrigation development, opines "whatever the methodological questions and the adjustment needed, it seems abundantly clear that the investment per hectare of irrigation potential created by a major irrigation project is a multiple (four fold or more) of the figure under minor irrigation project." Mitra also expresses a somewhat similar hunch. Both these views are contrary to Dhawan's hypothesis of relatively lower irrigation cost for major and medium schemes. But none of the participants in the debate has provided and carefully worked out estimates in support of their viewpoints.

3. The only attempt in this direction seems to be that by Kannan and Pushpagadan (1989) for Kerala state.

4. It may be pointed out here that the Government of India had been feeling for quite some time that the irrigation potential reported to have been created under major and medium schemes contains an element of over-reporting. To correct this over-reporting, irrigation potential was recently reassessed. The reassessment was done by carrying out corrections in the pre-Plan period and the potential created during the Sixth Plan. This has created some anomalies at the state level, wherein for some states such as Punjab, Tamil Nadu and West Bengal, irrigation potential created is reported as a negative figure for some years (see GOI 1989).

5. Pant (personal communication) indicates that the actual duration of project construction typically ranges between twelve and twenty years rather than the five to ten years usually shown in project planning documents.

6. More detail on methodology is found in Gulati, Svendsen, and Choudhury (1994).

7. Discussions were held with 7 or 8 senior engineers at the CWC.

8. Construction of an all India agricultural wage index is an exercise in itself which is carried out in this study on the basis of agricultural wages prevailing in 17 major states over the period 1954-1988. To develop an all India index, state level agricultural wages were weighted by the number of agricultural workers in respective states. Thus, the wage rates during 1954-64 were weighted with the number of agricultural workers as given in the 1961 population census. Likewise, wage rates of 1965-74 and 1975-88 were weighted by the number of agricultural workers as given in the population censuses of 1971 and 1981 respectively.

9. In reality, however, the pattern of expenditure distribution within a plan may differ from this assumed pattern as well as from state to state. The real overall trend, however, is controlled by the expenditure pattern from one plan to another which is reflected in actual data.

10. In a typical major project, it may happen that expenditure continues for say 10 years without creating any irrigation potential. Thereafter, expenditure continues untill say the 20th year, but creation of irrigation potential also continues from years 11 to 20. For every year from the 11th to the 20th, potential created may vary without any fixed pattern. Thus, in practice, for every project one observes a range of years during which expenditure has been incurred and potential created.

11. It may be emphasized here that the results of this exercise are likely to be very sensitive to this number, i.e., the exact period of gestation lag. One way to address this problem would be to carry out a sensitivity analysis corresponding to different lags and thus present the capital cost of irrigation development as estimates within a range. The other approach would be to cross check results of capital cost corresponding to a gestation lag of 12 years with those obtained from the project-specific-exercise. This latter approach has been adopted in the present study.

12. There are various other ways of getting social rate of discount reported in the literature. Social rate of discount is also sometimes equated to the marginal productivity of capital. For details see Sen, Marglin, and Das Gupta (1978).

13. This opens up a question whether the "centering" of results should be done at 1951-52 or 1963-64. Since the objective is to determine the development cost of irrigation, and since the irrigation potential is created in 1963-64 (corresponding to the expenditure incurred in 1951-52), the latter option has been selected.

14. In some projects, after potential creation had begun there were one or more years of zero potential creation, after which positive incremental potential has again been created. In such cases, no incremental expenditure has been attributed to these years. The entire expenditure against this year is distributed among the remaining years in the ratios of their created potenials to the cumulative potential from that year on, as described before. Thus for these intermediate years of zero potential creation, cost per hectare of cumulative potential creation increases only by the amount signifying PTP.

The treatment differs when these years of zero potential creation occur in the last few years of the period covered by the project. In these cases, the expenditure normally occurs after the entire UIP of the project has been created. Here, it is assumed that this expenditure is contributing towards greater potential utilization as well as improving the efficiency of the irrigation potential that has already been created. For these years, expenditure incurred in a year has been attributed to that year alone and cost based on cumulative potential created has likewise increased.

15. The raw data for analysis contained several negative values for potential creation, potential utilization and even for annual expenditures. Enquiries with the concerned authorities in CWC revealed that these negative values are adjustments for past over estimations. However, the exact years when this overestimation took place are not known. Consequently, the negative amounts have been distributed among the preceding years in the ratio of potential created in those years to the cumulated potential created by the project up to that year. Similar adjustments were applied for potential utilized and for expenditure incurred.

16. It may be mentioned here that the state-level estimates of capital cost (not reported here), which form the basis of regional and all India estimates, have to be interpreted with extreme caution. This is because in certian states, particularly Punjab, Tamil Nadu and West Bengal, negative figures for irrigation potential have been reported during certain plan periods. For example, Punjab reported creation of irrigation potential to the tune of (-)658 thousand hectares during the Third Plan (1961-66) and (-)32 thousand hectares during the Sixth Plan. Similarly, Tamil Nadu reported potential creation of (-)65 thousand hectares during Annual Plans (1966-69) and (-)8 thousand hectares during the Sixth Plan. West Bengal reported (-)39 thousand hectares in the Sixth Plan. If one applies these negative figures of potential creation on expenditure incurred, one gets absurd results of capital cost in negative. While one needs to probe deeper into the reasons that cause negative potential creation, for our purpose it would be more appropriate to treat regional costs as the relevant costs of irrigation development for those states which form that particular region. Under such a situation, therefore, regional cost structure would also differ depending upon which states are clubbed in which region. And there may be differences amongst engineers/economists in grouping of states in a particular region. While this study groups Rajasthan, Gujarat, Maharashtra and Madhya Pradesh in Western region, Svendsen (1991) treats this region comprising of only Gujarat, Maharashtra and Karnataka. He combines Madhya Pradesh with Rajasthan to form central region, while treats Uttar Pradesh as a separate region. Obviously his regional estimates of irrigation development cost, although derived on the basis of a different methodology, are not comparable with those derived in this study due to differences in the composition of regions.

17. This comment, and this paper, refer only to canal irrigation, or irrigation from surface sources. At present, the majority of irrigation in India is from groundwater sources, and its share is still increasing. Groundwater irrigation has an entirely different cost structure and the conclusions reached here can in no way be construed as applying to minor irrigation as a whole, a segment of the irrigation sector which includes groundwater.

18. It should be noted that the sample size in these cells is rather small.

19. Only one major project was begun in the ten sample states during the last, 1980-1984, period.

20. Missing values make interpretation of the 25, 50, and 75 percent completion lags difficult.

21. This last item is purely speculative.

Table 1 - Capital cost of major and medium scheme development: Planning Commission Estimates

Plan Period	Expenditure (B Rs.) Actual	at 1970-71 Prices[a]	Annual Average[b]	Potential Created (M.ha) Plan-Wise	Annual Average	Apparent Investment (Rs) Per ha. of Potential Created Actual	at 1970-71 Prices
1	2	3	4	5	6	7 (=2/5)	8 (=3/5)
First Plan (1951-56)	3.80	8.27	1.65	2.48	0.50	1,530	3,340
Second Plan (1956-61)	3.80	7.06	1.41	2.14	0.43	1,780	3,300
Third Plan (1961-66)	5.81	8.83	1.77	2.24	0.45	2,590	3,940
Annual Plans (1966-69)	4.34	5.26	1.75	1.53	0.51	2,840	3,440
Fourth Plan (1969-74)	12.37	11.24	2.25	2.61	0.52	4,740	4,310
Fifth Plan (1974-78)	24.42	13.92	3.48	4.01	1.00	6,090	3,470
Annual Plans (1978-80)	20.56	8.67	4.34	1.89	0.95	10,880	4,590
Sixth Plan (1980-85)	73.69	19.69	3.94	2.11[c]	0.42	34,924	9,330
Seventh Plan (1985-90) (anticipated)	113.43	16.82	3.36	3.13	0.63	36,240	5,380

[a] Expenditures at 1970-71 prices (column 3) are taken from the Report of the Working Group on Major and Medium Irrigation Programme for the Eighth Plan (1990-95) (p.II-10). It does not explain what sort of deflator it uses to convert yearwise expenditures at 1970-71 constant prices. Instead, it gives the source of the deflator as Perspective Planning Division in Planning Commission. Our enquiries with PPD revealed that they had worked out only an overall GDP deflator, and not the one specific to irrigation costs of major and medium irrigation schemes.

[b] The figures in column 4 are annual averages of real expenditure (at 1970-71 prices) incurred on major and medium schemes within the relevant plan.

[c] The figures of irrigation potential created in the Sixth Plan (2.11 M.ha) is the reassessed one, which is about 38 per cent lower than the one released earlier (3.40 M.ha).

Source: *Report of the Working Group on Major and Medium Irrigation Programme for the Eighth Plan*, 1990-95. (Government of India: 1989).

Table 2 - **Rate of inflation for capital cost of major and medium irrigation schemes in India**

Period	Decade	Agricultural Wages	Cement	Iron & Steel	Machinery & Transp. Equipment	Weighted Rate of Inflation
Weights →		0.6	0.2	0.15	0.05	1.00
1951-59	D1	1.541	4.250	7.083	3.614	3.018
1960-69	D2	7.351	4.850	4.595	3.924	6.266
1970-79	D3	7.658	9.128	11.073	9.140	8.538
1980-88	D4	12.100	9.186	11.028	7.511	11.127
1951-88	D1-D4	7.844	6.940	8.410	6.073	7.660

Sources : *Agricultural Wages in India* (various issues), DES, (Ministry of Agriculture, Govt. of India).
Revised Index Numbers of Wholesale Prices in India (various issues), (Ministry of Industry, Govt. of India).

Table 3 - **Planwise expenditure incurred, potential created, and potential utilized of major and medium irrigation projects in India**

State	Ultimate Canal Irr. Potential (1000 ha)	Pre-Plan PC-PU (1000 Ha) (R)	First Plan (1951-56)			Second Plan (1956-61)		
			Exp (MRs)	PC (1000 ha)	PU (1000 ha)	Exp (MRs)	PC (1000 ha)	PU (1000 ha)
NORTHERN REGION	*18,500.0*	*4,240.0*	*603*	*1,567.0*	*705.0*	*633*	*372.0*	*694.0*
Haryana	3,000.0	436.0	**	-	-	**	-	-
Punjab	3,000.0	1,251.0	319	1,238.0	576.0	382	100.0	375.0
Uttar Pradesh	12,500.0	2,553.0	284	329.0	129.0	251	272.0	319.0
EASTERN REGION	*13,380.0*	*721.0*	*1,154*	*288.0*	*178.0*	*700*	*982.0*	*796.0*
Assam	970.0	-	-	-	-	10	-	-
Bihar	6,500.0	403.0	156	125.0	87.0	265	269.0	180.0
Orissa	3,600.0	180.0	553	4.0	4.0	200	363.0	280.0
West Bengal	2,310.0	138.0	445	159.0	87.0	235	350.0	336.0
SOUTHERN REGION	*10,000.0*	*2,649.0*	*1,134*	*343.0*	*244.0*	*1,079*	*495.0*	*432.0*
Andhra Pradesh	5,000.0	1,331.0	375	77.0	59.0	574	181.0	129.0
Karnataka	2,500.0	217.0	387	48.0	21.0	274	140.0	97.0
Kerala	1,000.0	-	118	93.0	61.0	79	49.0	81.0
Tamil Nadu	1,500.0	1,101.0	254	125.0	103.0	152	125.0	125.0
WESTERN REGION	*15,850.0*	*950.0*	*844*	*286.0*	*151.0*	*1,205*	*292.0*	*145.0*
Gujarat	3,000.0	20.0	447	64.0	25.0	124	185.0	41.0
Madhya Pradesh	6,000.0	358.0	87	4.0	4.0	301	30.0	21.0
Maharashtra	4,100.0	252.0	-	21.0	17.0	527	47.0	21.0
Rajasthan	2,750.0	320.0	310	197.0	105.0	253	30.0	62.0
HILL REGION	*300.0*	*62.0*	22	*2.0*	*2.0*	*10*	*2.0*	*0.0*
Himachal Pradesh	50.0	-	-	-	-	-	-	-
Jammu & Kashmir	*250.0*	*62.0*	22	*2.0*	*2.0*	*10*	*2.0*	-
OTHERS	*445.0*	*0.0*	*6*	*0.0*	*0.0*	*173*	*0.0*	*0.0*
Grand Total	**58,475.0**	**8,622.0**	**3,762**	**2,486.0**	**1,280.0**	**3,800**	**2,143.0**	**2,067.0**
Taken by Planning Commission			3,800			3,800		

** Separate data not available for Haryana.

Table 3 - (Contd.)

State	Third Plan (1961-66)			Annual Plan (1966-69)			Fourth Plan (1969-74)		
	Exp (M Rs)	PC (1000 ha)	PU (1000 ha)	Exp (M Rs)	PC (1000 ha)	PU (1000 ha)	Exp (M Rs)	PC (1000 ha)	PU (1000 ha)
NORTHERN REGION	*743*	*517.0*	*857.0*	*644*	*258.0*	*332.0*	*2,553*	*854.0*	*698.0*
Haryana	**	864.0	818.0	105	56.0	78.0	659	173.0	159.0
Punjab	192	(658.0)	(301.0)	69	60.0	74.0	317	184.0	196.0
Uttar Pradesh	551	311.0	340.0	469	142.0	180.0	1,577	497.0	343.0
EASTERN REGION	*1,111*	*459.0*	*486.0*	*898*	*458.0*	*401.0*	*1,805*	*776.0*	*394.0*
Assam	14	-	-	19	20.0	6.0	40	13.0	6.0
Bihar	681	239.0	248.0	560	259.0	160.0	1,305	569.0	157.0
Orissa	262	127.0	129.0	204	131.0	147.0	209	59.0	113.0
West Bengal	153	93.0	109.0	115	48.0	88.0	252	135.0	118.0
SOUTHERN REGION	*1,635*	*582.0*	*292.0*	*1,146*	*168.0*	*358.0*	*3,073*	*303.0*	*379.0*
Andhra Pradesh	915	368.0	91.0	609	78.0	350.0	1,187	190.0	217.0
Karnataka	309	177.0	156.0	320	132.0	57.0	1,343	42.0	79.0
Kerala	103	15.0	15.0	92	23.0	23.0	274	41.0	41.0
Tamil Nadu	309	22.0	30.0	125	(65.0)	(72.0)	270	30.0	42.0
WESTERN REGION	*2,183*	*663.0*	*483.0*	*1600*	*640.0*	*474.0*	*4,890*	*644.0*	*437.0*
Gujarat	460	92.0	126.0	479	99.0	120.0	1,259	182.0	89.0
Madhya Pradesh	370	208.0	32.0	205	187.0	115.0	776	45.0	111.0
Maharashtra	631	129.0	85.0	580	119.0	32.0	1,663	266.0	77.0
Rajasthan	722	234.0	240.0	336	235.0	207.0	1,192	151.0	160.0
HILL REGION	*16*	*10.0*	*5.0*	*4*	*6.0*	*11.0*	*66*	*21.0*	*19.0*
Himachal Pradesh	-	-	-	-	-	-	-	-	-
Jammu & Kashmir	*16*	*10.0*	*5.0*	*4*	*6.0*	*11.0*	*66*	*21.0*	*19.0*
OTHERS	*72*	*0.0*	*0.0*	*6*	*0.0*	*0.0*	*35*	*10.0*	*10.0*
Grand Total	**5,760**	**2,231.0**	**2,123.0**	**4,298**	**1,530.0**	**1,576.0**	**12,423**	**2,608.0**	**1,937.0**
Taken by Planning Commission	5,810						12,370		

** Separate data not available for Haryana.

Table 3 - (Contd.)

State	Fifth Plan (1974-78)			Annual Plan (1978-80)			Sixth Plan (1980-85)		
	Exp. (M Rs)	PC (1000 ha)	PU (1000 ha)	Exp (M Rs)	PC (1000 ha)	PU (1000 ha)	Exp (M Rs)	PC(R) (1000 ha)	PU(R) (1000 ha)
NORTHERN REGION	*5,325*	*1,658.0*	*678.0*	*4,427*	*672.0*	*702.0*	*13,865*	*308.0*	*644.0*
Haryana	1,114	181.0	35.0	935	59.0	104.0	2,534	154.0	115.0
Punjab	496	109.0	108.0	532	56.0	56.0	2,089	(32.0)	(44.0)
Uttar Pradesh	3,716	1,368.0	535.0	2,961	557.0	542.0	9,243	186.0	573.0
EASTERN REGION	*3,480*	*847.0*	*758.0*	*2,954*	*384.0*	*289.0*	*12,527*	*176.0*	*520.0*
Assam	248	28.0	19.0	156	28.0	18.0	689	12.0	8.0
Bihar	2,039	437.0	319.0	1,645	150.0	165.0	7,192	76.0	455.0
Orissa	706	187.0	198.0	678	100.0	100.0	3,229	127.0	82.0
West Bengal	486	195.0	222.0	475	106.0	6.0	1,417	(39.0)	(25.0)
SOUTHERN REGION	*5,875*	*477.0*	*482.0*	*4,987*	*247.0*	*281.0*	*15,671*	*559.0*	*314.0*
Andhra Pradesh	2,691	213.0	175.0	2,577	154.0	149.0	7,296	305.0	173.0
Karnataka	1,885	161.0	235.0	1,384	66.0	99.0	4,135	185.0	66.0
Kerala	751	53.0	31.0	750	26.0	28.0	2,595	77.0	77.0
Tamil Nadu	548	50.0	41.0	277	1.0	5.0	1,645	(8.0)	(2.0)
WESTERN REGION	*9,721*	*1,016.0*	*545.0*	*7,845*	*580.0*	*198.0*	*29,600*	*1,008.0*	*710.0*
Gujarat	2,361	302.0	100.0	1,942	73.0	28.0	7,271	64.0	134.0
Madhya Pradesh	1,984	269.0	210.0	1,838	186.0	37.0	6,667	305.0	160.0
Maharashtra	3,616	286.0	163.0	2,923	112.0	(35.0)	11,872	461.0	346.0
Rajasthan	1,760	159.0	72.0	1,142	209.0	168.0	3,791	178.0	70.0
HILL REGION	*260*	*16.0*	*12.0*	*218*	*6.0*	*6.0*	*605*	*14.0*	*1.0*
Himachal Pradesh	15	-	-	41	-	-	62	6.0	4.0
Jammu & Kashmir	245	16.0	12.0	177	6.0	6.0	544	8.0	(3.0)
OTHERS	*502*	*0.0*	*0.0*	*349*	*6.0*	*6.0*	*1,419*	*44.0*	*23.0*
Grand Total	**25,162**	**4,014.0**	**2,475.0**	**20,781**	**1,895.0**	**1,482.0**	**73,688**	**2,109.0**	**2,212.0**
Taken by Planning Commission	24,420			20,560			73,690		

Table 3 - (Contd.)

State	Seventh Plan (1985-90)			Eighth Plan (1990-95)		
	Exp (M Rs)	PC(LA) (1000 ha)	PU(LA) (1000 ha)	Exp (M Rs)	PC(AD) (1000 ha)	PU(AD) (1000 ha)
NORTHERN REGION	*19,340*	*868.0*	*576.0*	*34,640*	*1,556.3*	*1,322.8*
Haryana	4,470	146.0	61.0	5,690	315.0	267.8
Punjab	2,320	181.0	105.0	3,680	167.3	142.2
Uttar Pradesh	12,550	541.0	410.0	25,270	1,074.0	912.9
EASTERN REGION	*23,440*	*644.0*	*675.0*	*46,060*	*1,176.8*	*1,000.2*
Assam	1,250	82.0	63.0	2,640	93.8	79.7
Bihar	13,760	281.0	410.0	24,560	459.8	390.8
Orissa	5,980	144.0	102.0	13,470	423.0	359.6
West Bengal	2,450	137.0	100.0	5,390	200.3	170.2
SOUTHERN REGION	*24,100*	*515.0*	*478.0*	*45,290*	*963.0*	*818.6*
Andhra Pradesh	13,980	184.0	159.0	23,840	585.8	497.9
Karnataka	5,440	171.0	235.0	11,030	205.5	174.7
Kerala	2,690	106.0	66.0	5,570	154.5	131.3
Tamil Nadu	1,990	54.0	18.0	4,850	17.3	14.7
WESTERN REGION	*43,780*	*1,035.0*	*1,042.0*	*97,150*	*2,001.8*	*1,701.5*
Gujarat	10,750	194.0	194.0	21,470	519.8	441.8
Madhya Pradesh	11,630	380.0	283.0	28,230	501.0	425.9
Maharashtra	14,980	239.0	401.0	31,040	472.5	401.6
Rajasthan	6,420	222.0	164.0	16,410	508.5	432.2
HILL REGION	*890*	*24.0*	*17.0*	*1,620*	*57.8*	*49.1*
Himachal Pradesh	100	2.0	-	350	20.3	17.2
Jammu & Kashmir	790	22.0	17.0	1,270	37.5	31.9
OTHERS	1,880	40.0	33.0	3,780	62.3	52.9
Grand Total	**113,430**	**3,126.0**	**2,821.0**	**228,540**	**5,817.8**	**4,945.1**

Source: *Report of the working group on major and medium irrigation program for the Eighth Plan*, 1990-95. (pp. A-11 to A-12, A-16 to A-17, A-108 for Expenditure data; pp. A-8, A-113 and A-108 for data on PC; pp. A-113 to A-114, A-108 for data on PU of VI, VII and VIII Plans). (Government of India, 1989).

Water and related statistics. (pp. 31 for PU data of I Plan to Annual Plans, 1978-80). (India: Central Water Commission, 1989).

Notes:

PC = Potential Created; PU = Potential Utilized; Exp = Expenditure Incurred; R = Revised; LA = Likely Achievement; UTs = Union Territories; AD = Adjusted: PC(AD) is derived as 0.75 of targeted PC assuming a slippage factor of 25 percent; PU(AD) is taken as 0.85 of PC(AD) assuming the utilization ratio to be 85 percent.

The category of OTHERS includes Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Sikkim, Goa, Union Territories and the Central Sector.

Parentheses indicate negative numbers.

Table 4 - All India: Capital cost of irrigation development, major & medium schemes; three year moving average

(Rs/ha;1988-89 prices)

Year	K1(PC) (E1/PC)	K2(PC) (E2/PC)	K3(PC) (E3/PC)	K1(PU) (E1/PU)	K2(PU) (E2/PU)	K3(PU) (E3/PU)
1	2	3	4	5	6	7
1964-65	36,104.6	47,884.3	63,096.3	37,941.3	50,320.2	66,306.1
1965-66	34,599.1	45,887.6	60,465.2	35,516.2	47,103.9	62,068.0
1966-67	33,093.6	43,890.8	57,834.1	33,091.1	43,887.6	57,829.9
1967-68	30,224.1	40,085.2	52,819.5	29,342.0	38,915.2	51,277.9
1968-69	28,656.4	38,006.0	50,079.8	31,186.0	41,360.9	54,500.5
Av.66-69	30,658.0	40,660.7	53,577.8	31,206.4	41,387.9	54,536.1
1969-70	27,088.7	35,926.8	47,340.1	33,030.0	43,806.5	57,723.1
1970-71	26,884.9	35,656.5	46,983.9	36,198.1	48,008.3	63,259.6
1971-72	26,884.9	35,656.5	46,983.9	36,198.1	48,008.3	63,259.6
1972-73	28,559.7	37,877.7	49,910.8	38,453.2	50,999.0	67,200.5
1973-74	25,126.7	33,324.7	43,911.3	35,353.5	46,888.1	61,783.7
Av.69-74	26,909.0	35,688.4	47,026.0	35,846.6	47,542.1	62,645.3
1974-75	21,693.7	28,771.6	37,911.9	32,253.9	42,777.3	56,366.8
1975-76	16,585.9	21,997.3	28,985.4	26,899.3	35,675.6	47,009.1
1976-77	16,585.9	21,997.3	28,985.4	26,899.3	35,675.6	47,009.1
1977-78	16,781.9	22,257.3	29,328.0	25,252.9	33,492.0	44,131.8
1978-79	16,978.0	22,517.2	29,670.6	23,606.4	31,308.4	41,254.5
1979-80	24,308.8	32,239.8	42,481.9	26,900.6	35,677.4	47,011.4
Av.74-80	18,822.4	24,963.4	32,893.9	26,968.7	35,767.7	47,130.4
1980-81	35,256.4	46,759.3	61,613.8	35,476.6	47,051.3	61,998.7
1981-82	46,560.4	61,751.5	81,368.8	44,392.4	58,876.0	77,579.9
1982-83	50,729.7	67,281.0	88,655.0	48,367.5	64,148.1	84,526.8
1983-84	51,086.2	67,753.8	89,277.9	48,707.4	64,598.9	85,120.8
1984-85	45,546.1	60,406.2	79,596.2	45,202.4	59,950.3	78,995.5
Av.80-85	45,835.8	60,790.3	80,102.3	44,429.3	58,924.9	77,644.3
1985-86	48,685.6	64,570.0	85,082.7	51,315.4	68,057.7	89,678.4
1986-87	51,825.1	68,733.8	90,569.3	57,428.3	76,165.1	100,361.4
1987-88	60,504.7	80,245.2	105,737.6	67,046.3	88,921.1	117,169.7
1988-89	60,504.7	80,245.2	105,737.6	67,046.3	88,921.1	117,169.7
1989-90	54,382.8	72,125.9	95,039.0	61,222.6	81,197.4	106,992.2
Av.85-90	55,180.6	73,184.0	96,433.3	60,811.8	80,652.5	106,274.3
1990-91	48,260.9	64,006.7	84,340.4	55,398.9	73,473.6	96,814.9
1991-92	42,214.4	55,987.5	73,773.7	49,664.0	65,867.6	86,792.5
1992-93	42,289.8	56,087.5	73,905.5	49,752.7	65,985.3	86,947.6
1993-94	42,365.3	56,187.5	74,037.3	49,841.5	66,103.0	87,102.7
Wt.Avg. 1963-95	35,084.8	46,531.8	61,314.1	42,049.5	55,768.7	73,485.4

Table 5 - Behaviour of regional capital cost [K1(PC)] of irrigation development (major & medium schemes; three yearly moving average)

(Rs/ha; 1988-89 prices)

Year	All India	Northern Region	Eastern Region	Southern Region	Western Region	Hill Region
1	2	3	4	5	6	7
1963-64						
1964-65	36104.64	24962.05	53802.51	41703.52	27266.68	46671.75
1965-66	34599.10	26645.54	46652.33	56696.93	23827.10	46671.75
1966-67	33093.56	28329.02	39502.16	71690.35	20387.52	46671.75
1967-68	30224.13	29063.89	27209.80	81497.17	18244.47	37141.99
1968-69	28656.42	23619.30	21975.53	74510.97	24099.66	24454.98
Av.64-69	30658.04	27004.07	29562.50	75899.50	20910.55	36089.57
1969-70	27088.71	18174.71	16741.25	67524.77	29954.84	11767.96
1970-71	26884.87	13678.75	16649.16	65725.15	34513.50	8610.70
1971-72	26884.87	13678.75	16649.16	65725.15	34513.50	8610.70
1972-73	28559.72	13308.03	17993.83	69808.63	39330.90	9432.70
1973-74	25126.72	10474.52	17497.28	61108.69	36103.02	10439.31
Av.69-74	26908.98	13862.95	17106.14	65978.48	34883.15	9772.280
1974-75	21693.73	7641.02	17000.73	52408.75	32875.14	11445.92
1975-76	16585.89	5178.22	15159.51	39625.33	24829.86	11630.53
1976-77	16585.89	5178.22	15159.51	39625.33	24829.86	11630.53
1977-78	16781.92	5870.57	16010.70	38127.24	23515.01	9562.52
1978-79	16977.95	6562.91	16861.88	36629.15	22200.17	7494.52
1979-80	24308.76	18028.21	44014.28	36356.56	23938.01	5555.71
Av.74-80	18822.36	8076.52	20701.10	40462.06	25364.67	9553.293
1980-81	35256.37	39069.78	67137.41	40206.21	30708.07	17130.53
1981-82	46560.44	60612.94	90881.15	44388.54	37771.72	28991.50
1982-83	50729.72	71383.14	88323.68	47345.36	41782.69	40723.26
1983-84	51086.18	71884.73	88944.29	47678.04	42076.28	41009.41
1984-85	45546.12	56425.64	67398.78	49035.86	41710.40	35313.65
Av.80-85	45835.77	59875.25	80537.06	45730.80	38809.83	32633.67
1985-86	48685.62	47836.09	51289.58	61724.26	51217.93	48777.61
1986-87	51825.11	39246.54	35180.38	74412.65	60725.46	62241.56
1987-88	60504.66	46116.07	40616.69	85743.22	70598.87	81401.26
1988-89	60504.66	46116.07	40616.69	85743.22	70598.87	81401.26
1989-90	54382.76	41931.08	36949.92	77526.40	62477.38	69111.81
Av.85-90	55180.56	44249.17	40930.65	77029.95	63123.70	68586.70
1990-91	48260.86	37746.09	33283.16	69309.58	54355.89	56822.36
1991-92	42214.40	32307.33	31613.20	58871.89	47309.55	41372.63
1992-93	42289.83	31053.56	33609.99	56651.03	48384.70	38212.34
1993-94	42365.27	29799.79	35606.79	54430.17	49459.85	35052.05
1994-95						
Wt.Avg. 1963-95	35084.82	22426.01	29440.26	55198.86	39210.86	35203.23

Table 6 - Number of sample projects, by state

NORTH			53
	U.P.	40	
	Punjab	6	
	Haryana	7	
EAST			86
	Bihar	55	
	Orissa	31	
SOUTH			57
	T.N.	29	
	Karnataka	28	
WEST			151
	Gujarat	51	
	Rajasthan	27	
	M.P.	73	
TOTAL			**347**

Table 7 - Capital cost of irrigation by state and region

REGION	State	Capital Cost Rs/Hectare	Weighted Average Capital Cost Rs/Hectare
NORTHERN	Haryana	16,120	15,586
	Punjab	8,805	
	Uttar Pradesh	16,916	
EASTERN	Bihar	26,043	26,424
	Orissa	28,881	
SOUTHERN	Karnataka	48,232	49,118
	Tamil Nadu	53,307	
WESTERN	Gujarat	44,004	34,436
	Madhya Pradesh	32,484	
	Rajasthan	28,880	
All India		**27,056***	
		28,988**	

Note: Cost is based on project specific data and is relative to cumulative potential created.
* This estimate has been obtained by using potential created by selected projects as weights.
** This estimate has been obtained by using potential created by selected states as weights.

Table 8 - Cost of irrigation in ten selected states

Project-Size Category ('000 Ha)	Area Irrigated by Sample Projects PC	Area Irrigated by Sample Projects PU	Cost Per Hectare for Sample Projects PC	Cost Per Hectare for Sample Projects PU
	---------'000 Ha---------		-----------Rs/Ha---------	
0-2	119.80 (1.07%)	124.86 (1.57%)	83,671.10	189,376.05
2-10	618.35 (5.52%)	494.55 (6.23%)	70,667.64	70,226.75
10-50	1,344.56 (12.01%)	945.96 (11.92%)	29,896.60	57,896.07
50-100	1,524.60 (13.62%)	763.65 9.62%)	31,746.91	51,458.08
100 and above	7,585.32 (67.77%)	5,609.23 (70.66%)	21,591.86	27,730.26
TOTAL	**11,192.63 (100%)**	**7,938.25 (100%)**	**27,348.48**	**38,797.58**

Note: Cost is based on project specific data and is at 1988-89 prices.

Table 9 - Comparison between major and medium schemes

State	Category	K(CPC) Rs/Ha	Percentage Difference
Rajasthan	Major	27,537	45.9
	Medium	50,908	
Gujarat	Major	37,371	44.6
	Medium	67,514	
Bihar	Major	24,606	39.7
	Medium	40,815	
Tamil Nadu	Major	45,102	24.1
	Medium	59,452	
Uttar Pradesh	Major	17,002	24.0
	Medium	22,379	
Karnataka	Major	47,513	18.9
	Medium	58,620	
Madhya Pradesh	Major	31,784	16.5
	Medium	38,058	
Orissa	Major	27,535	8.1
	Medium	29,958	

Note:- Cost is at 1988-89 prices and is derived from project specific exercise.

Table 10 - Average lags for project construction

System	Pure Lag		Estimated Simple Lag				Estimated Weighted Lag			
Type	Simple	Weighted	25%	50%	75%	100%	25%	50%	75%	100%
Minor	5.03	5.13	6.28	6.59	6.98	7.29	6.39	6.71	7.05	7.48
Medium	6.56	6.79	8.31	8.94	9.66	10.42	8.66	9.42	10.23	10.93
Major	7.64	8.23	10.62	12.17	13.60	16.66	13.05	15.01	17.86	22.84

Table 11A - Weighted lags from project initiation to first irrigation and 25, 50, and 75 percent area irrigated, *minor* irrigation schemes

	First Irrigation	25% Area	50% Area	75% Area	Number of Cases
1950-1954	5.00	6.00	7.00	8.00	1
1955-1959	10.80	12.30	13.30	13.80	2
1960-1964	7.00	8.00	8.00	8.00	1
1965-1969	5.08	6.08	6.08	6.29	8
1970-1974	4.99	6.26	6.44	6.96	29
1975-1979	5.15	6.39	6.90 (2)	7.03 (5)	37
1980-1984	4.08	5.54	5.37 (1)	6.20 (1)	10

Note: Numbers in parentheses are the number of cases eliminated due to missing data.

Table 11B - Weighted lags from project initiation to first irrigation and 25, 50, and 75 percent area irrigated, *medium* irrigation schemes

	First Irrigation	25% Area	50% Area	75% Area	Number of Cases
1950-1954	12.80	16.69	17.45	18.63	4
1955-1959	10.71	13.42	15.05	16.35	9
1960-1964	5.97	8.60	9.49	11.14	5
1965-1969	5.80	7.20	7.68	8.60	11
1970-1974	6.61	8.39	9.28 (2)	10.37 (4)	39
1975-1979	6.47	8.04 (5)	8.47 (15)	8.41 (26)	62
1980-1984	3.83	5.28 (2)	4.8 (4)	5.49 (4)	12

Note: Numbers in parentheses are the number of cases eliminated due to missing data.

Table 11C - Weighted lags from project initiation to first irrigation and 25, 50, and 75 percent area irrigated, *major* irrigation schemes

	First Irrigation	25% Area	50% Area	75% Area	Number of Cases
1950-1954	6.25	10.36	13.30	16.36 (1)	6
1955-1959	8.55	15.06	18.65	22.30	16
1960-1964	10.57	15.05	13.47 (1)	12.50 (3)	10
1965-1969	7.85	11.50 (1)	13.20 (2)	14.90 (3)	13
1970-1974	8.40	12.50 (5)	10.60 (11)	9.80 (19)	38
1975-1979	6.66 (1)	8.28 (4)	8.96 (9)	10.66 (12)	20
1980-1984	-	3.00	-	-	1

Note: Numbers in parentheses are the number of cases eliminated due to missing data.

Table 12-- Weighted average simple lags for project construction by region

Region	Scheme Type			All
	Minor	Medium	Major	
Northern	4.86	4.81	6.01	5.99
Eastern	5.24	5.49	9.97	9.64
Southern	5.26	6.70	9.25	9.04
Western	5.07	7.92	8.95	8.84

Table 13-- Aggregative and project specific estimates of capital cost by region

Region	Project-wise Capital Cost Rs/Hectare	Aggregative Capital Cost Rs/Hectare
Northern	15,586	22,426
Eastern	26,424	29,440
Southern	49,118	55,199
Western	34,436	39,211
All India	**28,988***	**35,085**

* This estimate has been obtained by using potential created by selected states as weights.

Note:- Costs are at 1988-89 constant prices.

References

Central Water Commission. 1989. *Water and related statistics*. Statistics Directorate. April.

Dhawan. B.D. 1988. *Irrigation in India's agricultural development: Productivity, stability, equity*. New Delhi. Sage Publications.

Dhawan. B.D. 1989. *Studies in irrigation and water management*. New Delhi: Commonwealth Publishers.

Dhawan. B.D. 1989. "Major and minor irrigation works : Cost aspects of the controversy". *Economic and Political Weekly*. Review of Agriculture (September 30).

Dhawan. B.D. 1990. *Big dams: Claims, counter claims*. New Delhi: Commonwealth Publishers.

Dhawan. B.D. 1990. *Studies in minor irrigation with special reference to ground water*. New Delhi: Commonwealth Publishers.

Dhawan. B.D. 1990. "Major and minor irrigation works". *Economic and Political Weekly*. Review of Agriculture (Discussion Column). (September 29).

Government of India (various issues). *Agricultural wages in India*. New Delhi: DES, Ministry of Agriculture.

Government of India (various issues). *Revised index numbers of wholesale prices in India*. New Delhi: Ministry of Industry.

Government of India (different years). *Annual Repprts of State Electricity Boards*.

Government of India. 1972. *Report of the Irrigation Commission*. New Delhi: Ministry of Irrigation and Power.

Government of India (different years). *Combined Finance and Revenue Accounts of the Union and State Governments in India*.

Government of India. 1989. *Report of the working group on major and medium irrigation program for the Eighth Plan (1990-95)*. New Delhi.

Government of India. 1989. *Report of the working group on minor irrigation for formulation of the Eighth Plan (1990-95)*. Proposals constituted by Planning Commission, Ministry of Water Resources, New Delhi.

Gulati. A., M. Svendsen, and Nandini Roy Choudhury. 1994. *Development cost of irrigation (major and medium schemes)*. NCAER, New Delhi.

Iyer. Ramaswamy R. 1989. "Large dams: The right respective". *Economic and Political Weekly* (Review of Agriculture). (September 30).

Kannan. K.P. and K. Pushpagadan. 1989. "Agricultural stagnation and irrigation in Kerala". *Economic and Political Weekly*. (May 13).

Mitra. A.K. 1990. Major and minor irrigation works. *Economic and Political Weekly*. (Discussion Column). (April 21).

Murty. M.N. 1982. "On the estimation of income distributional effects of investment in less developed regions of India". *Indian Economic Review*. 15(2).

Sen. A.K., P. Dasgupta, and S. Marglin. 1978. *Guidelines for project evaluation*.

Singh. Satyajit K. 1990. "Evaluating large dams in India". *Economic and Political Weekly*. (March 17).

Svendsen. M. 1991. "Sources of future growth in Indian irrigated agriculture". In *Future Directions For Indian Irrigation: Research and policy issues*, edited by Ruth Meinzen-Dick and Mark Svendsen. Washington, DC: International Food Policy Research Institute.