

This is a reissue of the memoranda originally issued in July last year. In this reissue certain mistakes that had crept in in the original because of the great haste in which it was cyclostyled have been corrected. A few minor stylistic revisions have also been carried out. One important revision is in the table on page 39. The internal rates of return in the original were calculated on the basis of "net" instead of "gross" benefits as required by the formula. So they have been recalculated and included in table on page 39. As this does not change their original ranking this revision makes no difference to the argument in the text.

Poona.
3 February 1963.

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D. R. Gadgil.

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Telegram: GOKHALINST.

Telephone: 56329

GOKHALE INSTITUTE OF POLITICS AND ECONOMICS,

(Founded by R.B. R.R.Kale, Satara)

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16th July, 1962.

Shri F. R. Gandhi,
Deputy Secretary to
the Govt. of Maharashtra,
Irrigation and Power Department,
Sachivalaya,
BOMBAY.

Dear Sir,

I enclose herewith the report of our study of the economics of the relative merits of utilisation of water for some irrigation and power projects.

We would have liked to take more time over the work. This would have enabled us to look more exhaustively for available data and examine more thoroughly all implications of our calculations. However, in view of your need to have the report early we are sending it now. In the circumstances, we would emphasise the tentative and preliminary character of the document.

Yours truly,

Sd. D.R.Gadgil

Director

BENEFIT-COST ANALYSIS

BY

PROF. N. V. SOVANI, JOINT DIRECTOR,
GOKHALE INSTITUTE OF POLITICS AND ECONOMICS,
POONA 4

The benefit-cost ratio is a particular application of the method used in everyday business for deciding whether an investment is worthwhile and for choosing between such worthwhile investments with due regard to the investment resources available. It is, therefore, capable of equally valid application to investments in all types of resource-use single or joint. In the case of single or multipurpose projects for the use of water resources like irrigation, flood control or hydro power, the benefit-cost analysis can be confidently used. The calculation of the benefit-cost ratio in respect of irrigation or other projects involves a number of problems and for dealing with them the evolution of comprehensive standard practices and conventions is necessary. This will have to be spelled out in great detail and will take time. I will only briefly deal here with some broad problems encountered in the calculation of this ratio in respect of irrigation projects in India. I will quote liberally from the U.S. Green Book for this purpose. I may be permitted to mention that most of the problems set out and discussed below have been concretely handled in my report on the Hirakud Dam.¹ It contains practical illustrations of

¹N.V.Sovani and N.Rath, Economics of a Multiple Purpose River Dam, being the report of an Investigation into the Economic Benefit Flowing from the Hirakud Dam, Gokhale Institute of Politics and Economics, Publication No. 38, 1961.

handling most of these problems.

Let me begin by briefly touching on the concepts of benefit and cost as used in economic analysis of this type. The aim of all productive activity is to satisfy human needs and desires. "All objects and activities which have the power of satisfying human wants and which may be increased or decreased in availability to satisfy such wants as a result of a project (usually referred to as goods and services)¹ together constitute the benefits resulting from that project." A summation of project effects, beneficial or adverse, to whomsoever they accrue in terms of market values (wherever possible) would approach full coverage of benefits from a public view point after making allowances in the summation for all transfers, cancellations, and offsets.

Costs that are a part and parcel of productive activity are also nothing but benefits foregone. When goods and services are utilised for any given purpose, say, an irrigation project, the economic effect of that action is to preclude their use for other possible purposes. Therefore, the economic cost of using goods and services for a given purpose is, in effect, the value of benefits foregone in the most likely other use to be expected. The cost, in terms of market value, of goods and services diverted to project purposes can be used as an adequate measure of benefits foregone.

Benefits and costs of irrigation projects accrue at various times and in various forms and in order to reduce them

¹Paranthesis added.

to a common basis for examining their ratio, it is found useful to distinguish certain types in them. The Green Book distinguishes the following :

"Project costs are the value of the goods and services (land, labour and materials) used for the establishment, maintenance, and operation of the project including allowance for induced adverse effects whether or not compensated for. In the irrigation project cited above, the project costs would be the costs of making irrigation water available to the farmer."

"Associated costs are the value of the goods and services, needed, over and above those included in the cost of the project itself, to make the immediate products or services of the project available for use or sale. In the cited example, the farmer's costs of producing the wheat (other than any charge for the irrigation water) would be associated costs."¹

"Primary benefits are the value of the immediate products or services resulting from the measures for which project costs and associated costs were incurred. In the irrigation project illustration, the primary benefits are the value of the wheat produced by the farmer. The procedures through which these primary benefits (and secondary benefits described below) are translated into net benefits attributable to a project are discussed in subsequent paragraphs."

¹Because of special difficulties connected with the estimation of these costs in India as discussed toward the end of this note it is suggested that the "project costs" in India should also include the costs of using productively the irrigation water by the ultimate consumer such as those of construction

"Secondary costs are the value of any goods and services (other than those covered by project and associated costs) which are used as a result of the project. These include the costs of further processing of the immediate products or services of the project and any other costs, over and above project and associated costs, stemming from or induced by the project. In the irrigation project example, the costs of transporting the wheat, elevator and milling costs, bakery costs, and the costs of distribution to consumer would be secondary costs."

"Secondary benefits are the values added over and above the value of the immediate products or services of the project as a result of activities stemming from or induced by the project. In the cited example the value of the bread over and above the value of its wheat content would be a secondary benefit. The portion of this secondary benefit creditable to the project is discussed later in this chapter.²

This classification of benefits and costs rests mainly on the chronological sequence in which they arise and the closeness of their connection with the investment whose effects are being studied. But at every remove the benefits and costs become more difficult to identify as other factors besides the originating investment come growingly into the picture. It is recognized that the measurement of benefits and costs at the

of field channels, preparing the lands for irrigation, increased credit necessary for growing irrigated crops, etc. This implies of course, a far more detailed and comprehensive planning of irrigation projects than is common at present.

²pp. 8-9.

primary level is easier and can be fairly precise while that at the secondary, tertiary, etc. levels it becomes progressively difficult and imprecise. A distinction is also drawn between tangible and intangible benefits and it is conceded that the measurement of the latter is very difficult and imprecise. The more imprecise the benefits are, the more they are capable of being misused in the justification of projects, as the history of federal and other works the U.S.A. is witness to. I am therefore proposing, that in regard to irrigation projects we should begin by restricting their evaluation to primary tangible benefits and costs only. Later on, when the methods of calculations of benefits and costs become familiar and as more data are gathered and accumulated the secondary, tertiary, etc. benefits and costs and intangibles may be included in these calculations. I am confining myself below to problems of the measurement of primary tangible benefits and costs of irrigation projects.

When an irrigation project is undertaken the project costs are the first to be incurred and until the project is completed and ready no economic benefits accrue. When an irrigation work begins to function it results in increased agricultural production through more extensive and/or intensive use of land. The increase due to irrigation is obtained by deducting from this the volume of agricultural production in the area before or without irrigation. In other words increases in production due to an irrigation work are measured by comparing the volume of usable agricultural production from the area under future conditions with and without the project. This difference is converted into monetary values by application of expected market

prices for each product.

"This increase in production results from the project and from the application of associated resources. The costs for associated resources for irrigation are the additional costs of private farm investment and farm operation necessary to utilize the project service. These associated costs may be measured in terms of increased operating costs for production, interest, investment, maintenance, etc. The primary gross benefits attributable to the project from increased production are the value of increased production less the associated costs."

The following specific problems thus arise in estimating primary benefits and costs of irrigation projects.

Benefits

1. Agricultural production in the area to be irrigated by the project before or without the project.
2. Agricultural production in the area after or with irrigation.
3. The prices to be used for converting (1) and (2) into monetary terms.

C o s t s

1. Project costs or capital costs.
2. Operating costs (annual) of irrigation works, canals, etc., including interest on sum-at-charge.
3. Cost of agricultural production with and without irrigation.
4. Prices to be used for estimating costs.

Having solved these problems the benefits and costs have

to be reduced to a common time basis for comparison and it is most convenient to express benefits and costs in terms of their equivalent average annual values. In respect of costs the problem is the conversion of capital costs or project costs into annual recurring ones. There is also the question of prices to be used for calculating benefits and costs. We will consider the problems in the order listed above.

B E N E F I T S

1. In calculating agricultural output and input without the project, we have to have information about the area to be irrigated, the crop pattern before irrigation, per acre yields of different crops grown and the inputs or costs per acre of different crops. The area is easily available in most projects. The distribution of the area under various crops is available in the Agricultural Statistics and season and crop reports of almost all States in India. For the outputs and inputs of different crops per acre it is necessary to have data furnished by cost accounting and/or farm business surveys carried out in the very area or in a contiguous comparable area with broadly similar agricultural and other conditions. In recent years thanks to the several surveys carried out under the Food and Agricultural Ministry and in connexion with the Rural Credits Survey of the Reserve Bank of India a large part of the country has been covered by such surveys. The Ministry has published reports of surveys in the Punjab, Bengal, Madras, Bombay, Madhya Pradesh and Andhra Pradesh and the work is continuing.

The agro-economic centres at Delhi, Shantiniketan, Gwalior, Anand, Poona and Madras have been and are carrying out village-surveys for the last several years on a continuing basis and data from these are available. The Rural Credit Survey carried out farm business surveys in 75 districts of India. These and other data that exist are sufficient for the purpose in view and these data are increasing in coverage almost every year. No difficulty need be therefore envisaged in this connection.

2. In estimating agricultural production with irrigation we have to begin by ascertaining the area irrigated, the intensity of irrigation or duty, the crop pattern or distribution of the irrigated area among different crops and their per acre costs and yields. The project estimates usually provide the first two, some crop pattern is also arrived at that stage or later and is easily available. The inputs and outputs will have to be estimated from the farm business and/or cost accounting surveys of comparable irrigated areas within the irrigation command or outside. In most of the surveys mentioned earlier such information would be readily available though it will have to be carefully used after sifting and adaptation to this purpose. With the growing information on this score and some familiarity in handling these data for the purposes mentioned the calculation would present few difficulties. From the gross production thus estimated has to be deducted the gross output of the area that is lost to cultivation because of the construction of the irrigation project, such as areas lost due to submergence under storage tanks, new canals, etc. The production

of this area will have to be estimated under unirrigated conditions and this can be done along with and on similar lines as the calculation of inputs and outputs without irrigation under (1).

3. In regard to prices, a problem that is common to both benefits and costs, the recommendation of the Green Book is : "In order to satisfy the various purposes to be served by benefit-cost analysis the use of prices reasonably expected to prevail at the time of benefit and cost accrual is recommended. For installation costs, prices expected during the construction period should be used. This may or may not mean the use of current prices prevailing^{at} the time of the investigation depending upon how soon the construction will begin and the extent of price changes anticipated in the interval. In calculating costs for operation, maintenance, and minor replacements, the prices should be the average prices estimated to prevail over the life of the project." ¹ This is, as I have said elsewhere, a counsel of perfection because no one can with any degree of reasonable certainty forecast the prices over a full century or even over half a century, which are usually taken to be the limits of the life of irrigation project. In practice, therefore, it would be quite reasonable to use the average prices of the preceding 5 years for this purpose. If this is not possible an average over a still shorter period should be used, at the extreme using prices prevailing in a single year.

¹ Ibid., p. 20.

C O S T S

1. In regard to project costs the method to be adopted for reducing them to an annual basis must be discussed. In ordinary business this is done by calculating depreciation and the same method may be used here. When depreciation on capital works is charged every year, at the end of the life of the works the total depreciation fund is expected to amount to a sum equal to the original investment. This is familiar enough but the important question in respect of irrigation works is to determine their life period. An extension of the life period lowers the rate of depreciation and therefore costs and vice versa. It is therefore necessary to develop an agreed convention in this regard. The Green Book recommends that "the maximum period of analysis be the expected economic life of the project or 100 years whichever is shorter."¹ A Congressional Committee in U.S. in 1952 has laid down a uniform rule by fixing the life of projects for such calculations at the economic life of the project or 50 years whichever is less. Any of these two conventions should be agreed upon.

2. In respect of current costs the problem of the appropriate rate of interest on the sum at charge is important. The Green Book recommends that the rate of interest prevailing on long term Government bonds be used for this purpose. In an underdeveloped country this rate of interest is unnaturally low and does not reflect the real scarcity of capital or its social value. It is also necessary to allow for a certain risk factor

¹ Ibid., p. 26.

in regard to benefits or to allow for the uncertainties of their accrual throughout the life of the project which is generally done by an added percentage on the interest rate. Taking all elements into account Tinburgen suggests that a rate of 10 per cent per annum should be adopted for such calculation in underdeveloped countries. We should adopt that rate in India.

ASSOCIATED COSTS

The problem of estimating costs of agricultural production with and without irrigation has been touched upon, earlier but it raises a new problem in our present conditions which we have to discuss at some length.

The problem mainly arises because of the nature of the farm business data (which are the more amply available in India today as contrasted with the cost accounts data) and the nature of the estimates of inputs and outputs, with and without irrigation. The farm business data are gathered with reference to the total farm business of the farmer (the total area operated by him, all the crops grown by him, all labour employed by him, etc.) and thus gives information about the business as a whole and not about its component parts separately, such as for example the inputs and outputs in any particular plot operated among others by a farmer, or the input and output of any particular crop grown by him. The farm business surveys furnish information regarding the production of each crop grown and so easily yield data regarding the per acre yields of different crops. In regard to inputs of particular crops, they do furnish data about seed and plants, manure, or broadly materials

used up in the process of production, but the labour inputs, rents, wages and all other overhead items of inputs are available for the farm business as a whole and not for individual crops. As a result it is not possible to estimate the inputs (or cost to the farmer) of individual crops from farm business data.

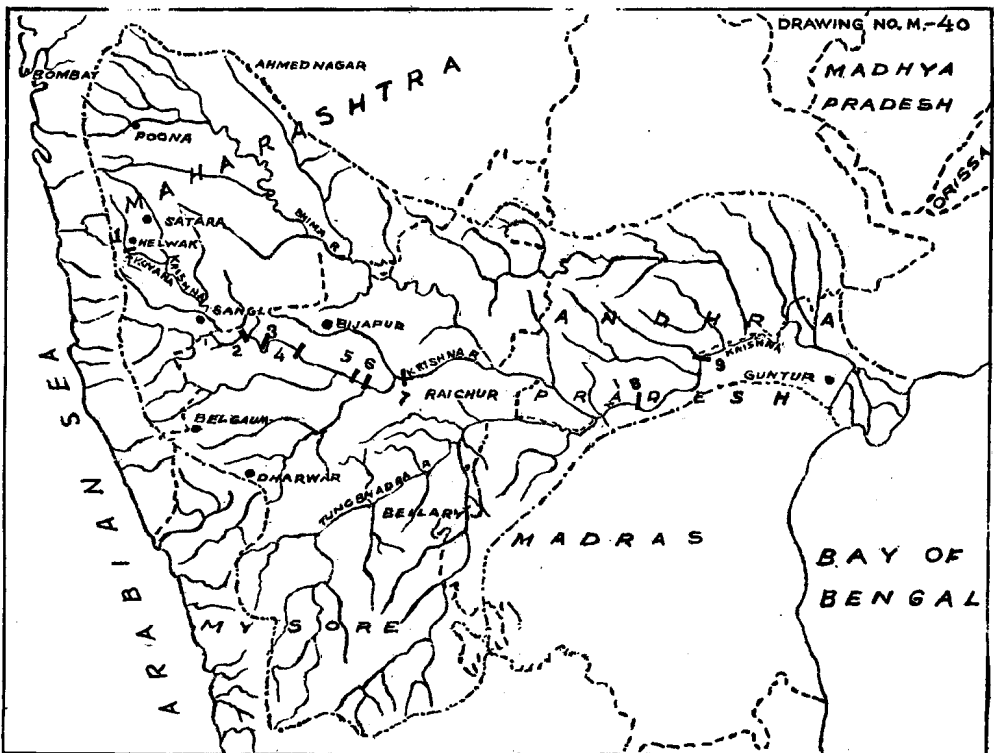
On the other hand the nature of the estimate of production with irrigation in our conditions is usually of the type of estimating the crop yields and their value for a given area with a given crop distribution. In this sort of calculation the inputs and outputs of individual crops are indispensable. These as we have seen are in that form not derivable from the farm business surveys

The way around this difficulty is to adopt the more comprehensive view point of national income accounting in the place of the narrower one of farm business as such. In any case, output estimated in such calculation takes account of gross income of farmers from crop production only. The income from livestock, wages in other employment, etc. are left out. So in any case we do not calculate the incomes of farmers in the area as such. In the same way, we would be justified in not calculating the cost (or inputs) of growing the crops to the farmer. Instead we can calculate the cost to the economy of growing those crops. These consist of the materials used up in the process of production, all other costs or inputs being regarded as in the nature of transfer payments which come out of the total crop output. As noted earlier these are furnished cropwise by the farm business surveys. National income calculations also use this concept for arriving at total income in agriculture from production data. On the output side we neglect all other

receipts than from crop production and on the input side we neglect all other inputs of materials. They do not cancel one another but compensate each other only to an extent that cannot be precisely indicated.

This problem does not arise where the estimates of production with or without irrigation are made by blowing up for the area concerned the data furnished by a fully representative sample of condition without and with irrigation. This is for example the case in the five surveys done at the instance of the Committee. But this is possible in regard to projects that have been in operation for more than two decades. This is not impossible but difficult to do in regard to projects yet to be undertaken and these are the ones with whom we are mainly concerned here. The procedure suggested above, therefore, can and should be accepted as the best under the given circumstances.

DRAWING NO. M.-40



- 1 KOYNA AT HELWAK
- 2 KRISHNA AT AINAPUR
- 3 " HALLIHAI
- 4 " HIRE PADVALGI
- 5 " CHIMALGI
- 6 " ALMATTI
- 7 " NARAYANPUR
- 8 " SRI-SAILAM
- 9 " NAGARJUNSAGAR.



REFERENCES

CATCHMENT SHOWN THUS	
STATE BOUNDARY	
SITES	

GOVT OF MAHARASHTRA
 WATER RESOURCES INVESTIGATION CIRCLE
 KRISHNA BASIN
 INDEX MAP
 SHOWING
 LOCATION OF PROJECTS CONSIDERED FOR
 ALTERNATIVE USE OF KOYANA WATERS
 SCALE 1" = 50 MILES.

ECONOMIC EVALUATION OF ALTERNATIVE USES OF WATERFOR IRRIGATION AND POWERPART - I

The problem as it arises in Maharashtra is an example of the ideal type of economic problem : the most economical employment of a scarce resource - for all of whose end-products there is sufficient demand - capable of alternative applications given the end of maximising economic gain. The opportunity cost of using water for irrigation is those goods and services which it would have produced had it been used for generating power. But the total production or output resulting from either type of use of water is only possible by incurring costs such as those of construction of a dam exclusively for either purpose together with the cost of accessories and the operating costs, including depreciation, etc. For comparing the economic efficiency of the two alternative uses of water, the benefits as well as costs associated with them will have to be considered. An index of economic efficiency can be the output per unit of input provided the scale is not very dissimilar. There are further complications in this which, however, need not be discussed or raised at this preliminary stage.

The assessment of costs and benefits of the alternative uses of water can be done along fairly standardised lines as evolved in the U.S.A. and exemplified for Indian conditions in the Hirakud Report. This assessment will have to be made for each dam or project or valley separately so as to maximise the

comparability of the costs and benefits resulting from alternative uses of water. A total picture of comparative efficiency can be built up later.

But even to validate such a comparison in the first place, it is necessary to examine the alternatives available for providing the same services of irrigation or power and to satisfy ourselves that the use of water in the way in which it can be used exclusively for one purpose only is the one that is the most economical among the available and technically feasible alternatives. For example, whether the same extent of irrigation cannot be provided by the development of well irrigation in the tract sought to be served by an irrigation dam? So too, whether the same amount of power cannot be made available over the same region by using coal, oil or nuclear fuel, more cheaply than by a hydel dam? In all these comparisons only costs (including operating costs) can be compared as the output may be assumed to be the same for the same kind of facility made available. The comparison discussed earlier will be valid only if the alternatives being compared are also the most economical among alternatives catering to the same needs. If this is not so, there is no case for comparison. There is only one use economically possible; the other stands rejected at a preliminary stage of examination.

This all or none proposition, however, is not the end of the story. It is, as indicated at the beginning of this note, the more or less ideal economic problem that we have been so far considering. Though this is initially necessary to fix

ideas and clarify issues it must be recognized that it will rarely be presented in reality in this ideal or pure form. Ordinarily it would come up in a mixed form. In a river valley, for example, some water cannot be impounded and has to be allowed to flow downstream. Of the remaining, only a part can be used for irrigation and another part only for power. The remaining water supply can be used for irrigation or power. This gives rise to the ideal problem discussed before. But there are always possibilities of using this water partly for power and partly for irrigation. It is quite possible that by so using the water the total of optimum benefits derived from each of the uses may be more than those derivable from the exclusive use of water for one or the other purpose only. How to allocate this water between the two competing uses so as to maximise total gain would be again an ideal economic problem only if there was perfect divisibility of water, i.e. any amount of water out of the total available could be used for either purpose. But this is never so and in each valley there might be only two or three alternative designs corresponding to two or three divisions of water between the two uses. In practical terms the problem will be : Which of these designs maximises gain and whether any of them pushes it beyond the level realisable from the exclusive use of water for either purpose? These problems also will have to be examined thoroughly for a comprehensive assessment of the total problem. However they do not present any new problems of methodology. They can be tackled along lines

indicated earlier.

I have spoken of economic valuation and economic efficiency above. But for final assessment social valuation and social efficiency (which is really a further refinement of the economic) must be considered more decisive. This will involve the consideration of such things as the length of the period of construction of a dam for different purposes, the foreign exchange component of the costs, the employment potential of each of the designs, the indirect bearing of end-products on the cumulation of economic growth, etc. These will have to be tackled partly by well-known practices and partly by evolving new ones suitable to each set of conditions. This will come, however, at the final stage of the inquiry and need not be discussed in detail at this stage.

I have hastily put together the above outline and may be I will have to revise and rewrite it after I have been able to give more thought to it. However, this can serve as a brief working note at this stage. I also indicate below the data that would be required for the assessment as outlined above. This is not an exhaustive list but again only a tentative one hastily put together. I am sure, much more data will be necessary and demanded as the analysis proceeds.

Data For each project or sight or valley

I. Irrigation : (a) Canal, (b) Well

(a) Canal Irrigation

Overall data for each river valley :

(i) Total available water supply.

- (ii) Water that can be stored and that which has to be allowed to flow downstream.
 - (iii) Water that can be used for irrigation only.
 - (iv) Water that can be used for power generation only.
 - (v) Water that can be used alternatively for either; alternate dam designs that are possible and the allocation of water for each purpose in each design.
- (1) Cost of construction of the dam (of different designs) together with periods of construction of each. (Foreign exchange component in each).
 - (2) Cost of construction of canals and distributories. (The employment of labour in each).
 - (3) Operating costs of the dam and the canals: (interest on capital, wages, depreciation, etc.)
 - (4) Total water impounded and amount made available in the field (data for losses due to evaporation, seepage, etc.).
 - (5) Area commanded and irrigated - perennial and seasonal.
 - (6) Acreage under different crops in the irrigated and non-irrigated area in the area under command.
 - (7) Acreage under different crops in the areas adjoining the commanded area.
 - (8) Production and costs of production (farm business data) for (6) and (7).
 - (9) Area of cultivable land lost under the lake created by the dam.
 - (10) Processing of agricultural produce such as sugarcane into sugar - in the commanded area - Total production and its costs.
 - (11) Processing of the processed product if any :
Production and costs.

(b) Well Irrigation

- (1) Cost and period of construction.
- (2) Operating costs.
- (3) Area under different crops.
- (4) Production and its costs (farm business).
- (5) Processing of agricultural produce :
Production and costs.
- (6) Further processing if any of the processed products.

II. POWER : (a) Hydel, (b) Coal, (c) Oil, and
(d) Atomic fuel.

- (a) (1) Cost of construction of the dam (exclusively for power), and the period of construction (data regarding all other alternative designs possible) (Foreign exchange component).
 - (a) (2) Cost of transmission lines, etc. (Foreign exchange component).
 - (a) (3) Operating costs of the dam and the transmission system (interest on capital, wage, depreciation, etc.) (Employment of labour).
 - (4) Use of tail race water : costs and benefits.
 - (5) Proceeds of sale of power to different consumers.
 - (6) Industrial units using power : their production and costs : value added : (Employment of labour).
- (b), (c), and (d) :
- (1), (2), and (3) as in (a).
 - (5) and (6) in (a) can be taken as common to all.
 - (7) Costs connected with ^{the} waste products of these fuels.

PART IIECONOMIC EVALUATION OF ALTERNATIVE USES OF
WATER FOR IRRIGATION AND POWER

I

In the first memorandum sent to you on this subject the analysis necessary for assessing the economics of the alternative uses of water and its procedure have been spelled out. The same ground need not be covered here again. It may be however, recalled that in that memorandum we had said that the problem will have to be tackled in two stages :

To validate a comparison regarding economic productivity of irrigation and hydrogeneration of power by using the same water, we must first satisfy ourselves that these are the cheapest means of providing the respective services.

Once this is found to be so, the way is clear for comparing the productivity of each use on the basis of the benefit-cost ratios of alternative uses.

In this tentative and preliminary note we shall only consider the case of koyna waters, firstly, because firm data are available in respect of the koyna project in a greater degree than in respect of the other schemes. Secondly, the Koyna project represents the problem of alternative uses in a rather sharp manner, in fact sharper than in respect of any other waters.

In considering the case of Koyna waters we are relying on the data furnished by you. We have had very little time to look into it in detail but as most of it is more or less data

of a technical engineering character, we are perhaps not technically competent to scrutinise them to any great extent. The data we have used for estimating the agricultural production of the different irrigation projects based on Koyna and/or Krishna waters have been partly provided by you, particularly the data regarding the area irrigated, the crop pattern, etc. The data regarding crop yields with and without irrigation and that regarding the costs of cultivation to the economy of these crops, have been derived from various sources, partly from the surveys conducted by the Institute in relevant areas and partly from published data. The sources of these data have been indicated in every case so that the basis of our calculations should be open for a thorough scrutiny at any stage. We would, however, emphasise that we have had very little time to go into all these matters as thoroughly as we would have liked, or to explore the availability of ampler and more detailed data on all these counts. It is because of this that we are deliberately calling this study as tentative and preliminary. Even so the calculations are fairly indicative of the total dimensions of the problem. We venture to think that the detailed and more refined calculations will not make a material difference to the overall picture.

II

In the note on benefit-cost ratios, submitted to the Committee of Direction for the Evaluation of Benefits of Irrigation Projects (Planning Commission) and attached herewith,

the procedure for calculating costs and benefits of irrigation have been discussed. The procedure for estimating costs and benefits of hydro-electric projects was not indicated there. As we shall have to deal with this estimation here it is necessary to spell it out a little to begin with.

The U.S. Green Book lays down : "The primary benefits of power produced by a project are the value of the power to the users as measured by the amount that they would be willing to pay for such power in the absence of that project."¹

In a state-owned power station this is the sum that Government would realize every year through sale of power at the going rate of power from alternative sources. It is the direct return to Government on its investment in the power project concerned. The other economic and social benefits of electric power resulting from increased industrial production or increased civil amenities such as lighting, pumping, etc., also accrue simultaneously. The sale proceeds are really a fraction of these latter and they ultimately come out of it. We have here calculated only the proceeds of sale of power. The other benefits, for calculating which adequate information was not available, have been left out.

In the case of irrigation, however, the benefits have been equated with the net increase in total agricultural production due to irrigation. The proper comparison with reference to alternative uses would have been the returns to government on the irrigation project through water rates and betterment levy,

¹ Proposed Practices for Economic Analysis of River Basin Projects, prepared by the Sub-Committee on Benefits and Costs, Report to the F.I.R.B. Committee, Washington, 1950, p. 49.

or what is usually calculated as the financial return on capital by engineers planning irrigation projects. We, however, had not at our disposal the relevant information regarding the proposed water rates, etc., and we could not calculate the return to government in regard to irrigation schemes. As contrasted with electricity rates there is also no market check for water rates. We have made the more comprehensive calculation of the addition to total social income consequent on the construction of irrigation projects. The total water rate and/or betterment levy collections would be only a fraction of this increase in social income. In comparing the benefits of irrigation and hydroelectricity in the respective ways indicated above, we are comparing a whole benefit (irrigation) with a fractional benefit (hydroelectricity).

As a result the comparisons are already loaded in favour of the irrigation use. The calculations are further weighed in favour of irrigation in another way. Irrigated agriculture requires a considerable initial investment in the preparation of land for irrigation construction of field channels, etc., by the peasant. In our calculations we have not included this item on the cost side and consequently the benefits of irrigation have been to that extent overstated.

III

We have so far detailed the methods, procedures and problems involved in the calculations made here for comparing the economic performance of the two alternative uses of Koyana - Krishna water. We can now proceed to the assessment proper of

the alternative uses and as indicated in our earlier note, the first question to decide is whether canal irrigation and hydrogeneration are each the cheapest of the alternative means of providing irrigation and electricity respectively. The only alternative means of irrigation to canal irrigation is well or tank irrigation and such information as is available regarding the costs of these would indicate that canal irrigation is much cheaper, more reliable and sustained than well or tank irrigation. It is also not possible to provide irrigation over extensive localised areas in an intensive manner by wells or tanks. That can be only done by canal irrigation. We may therefore presume that canal irrigation is the cheapest of the alternatives for providing irrigation and can be compared with the cheapest means of providing electric power.

In respect of the generation of power by alternative means we have more firm data. Of the fuels that can be used for generating power the experience all over the world and in India clearly shows that as compared to oil, atomic fuel, etc., coal is cheaper. The cost of generating power by coal burning should be compared with that of hydrogeneration. The following figures regarding costs of alternative power generation supplied by the Government of Maharashtra are relevant in this connection.

I. The cost of power generated in coal burning thermal stations :

	Cost of generation per kwh.
* (1) Gangakhed (60 Megawatts)	5.4 nP.
* (2) Nasik-Kalyan (300 Megawatts)	3.9 nP.
+ (3) Trombay (Unit III: Set up in 1969 - 60 Megawatts)	4.72 nP.

* Estimated. + Actual.

II. Cost of generation of power generated by Koyna Hydro-electric Scheme (estimated)

	Cost of generation per kwh.
(a) With 07.5 TMC diversion to the west	1.9 nP
(b) With 100 TMC diversion to the west	1.4 nP.
(c) With 118 TMC diversion to the west	1.25 nP.

We may reasonably assume that the cost of generation and selling price of thermal (coal) power will not be on an average lower than 4.5 nP. per kwh.¹ Considering such data as are available in respect of the relative cost of hydro and thermal power elsewhere in India, we can confidently assume that hydropower is the cheaper alternative in this context.

It may also be emphasised that the calculations of cost of thermal power made above are based on the coal prices prevailing in 1960. If they go up still further, the relative advantage of hydrogeneration goes up too. The trend of coal

¹In estimating the benefit-cost ratio of the Shri Shailam project the cost of generation of thermal power in the Shri Shailam area is taken to be 2.7 nPs. per kwh as compared to 4.5 nPs. in the Koyna-Bombay region - - because Shri Shailam is very near the Singareni collieries and coal is available in that area at a much cheaper price than in the Bombay - Koyna region. This makes for a saving in freight charges. For every 1.5 lbs. of coal which is required for generating one kwh of power, this saving in the Shri Shailam area amounts to about 1.8 nP. By deducting this from 4.5 nP, the corresponding thermal rate in the Bombay Koyna area, we have arrived at 2.7 nP. per kwh as the generating and selling rate for thermal power i.e. power other than hydro in the Shri Shailam region.

prices from 1947-48 has been consistently upwards.

Apart from cheapness, there are a few invisible benefits of hydropower as compared to thermal power. Firstly, thermal fuels are capital fuels i.e. they are a non-reproducible stock in the crust of the earth and are exhaustible. Hydel power is regarded as an income fuel the source (water) of which is renewed and regenerated every year. Hydrogeneration saves so much of an exhaustible natural resource like coal. From such data as are available it seems that for the generation of one kwh. of electricity 1.5 lbs. of coal have to be burnt. With 67.5 TMC diversion at Koyna 2600 million kwh. would be generated annually and to generate the same volume of power roughly 17 lakhs of tons of coal will have to be consumed. With 11.8 TMC diversion, Koyna will generate 4530 m.kwh. of energy which can be produced by using nearly 30 lakh tons of coal annually. The coal saving is thus substantial. Secondly, this coal would have to be transported to the Bombay Koyna area annually. As hydrogeneration avoids this, it also effects a substantial saving in transport capacity. At a time when transport has become a bottleneck the economic significance of this saving in transport capacity can hardly be overstated.¹

IV

We can now pass on to the second question of comparing the benefit-cost ratios of the alternative uses of Koyna water. We

¹Of these two invisible benefits the first will also accrue to the Shri Shailam Project but the second will not because the thermal station can be located at the nearby collieries themselves without much transmission losses.

first present the calculation for the koyna project as sanctioned now and then for the koyna project, if and when it is sanctioned in its entirety. We then proceed to calculate the benefit-cost ratios for the koyna water used in the east for irrigation at various places downstream. We will, for the sake of fair comparison, suppose that the same volume of water that will be used for hydrogeneration will be available at the various sites for irrigation, subject of course to lake and transit losses. In the case of Shri Shailam and Nagarjun Sagar Projects, the costs, etc. are available for full use of water potential for which they are designed. The cost, etc. for use of Koyna waters there could therefore be had only on a pro rata basis. Accordingly there was no point in calculating the benefit-cost ratio for that part of water available from Koyna only. We have, therefore, calculated it for these projects as a whole. This makes no difference for purposes of comparison.

In the calculations of these benefit-cost ratios we have followed uniform practices in regard to (1) interest on capital and (2) depreciation. It is well known that capital, though scarce, is undervalued by current interest rates in the underdeveloped countries and to compensate for this, i.e. to take into account the real social cost of capital in economic terms, it has been recommended that capital investment in such countries should carry an interest rate of, say, 10%. In all cases here, interest is charged at 10% per annum.

In regard to depreciation, we have followed the current practice in India of charging 1% depreciation on civil works. On electrical installations the depreciation rates currently

charged in India vary from 4.5% on switch gears and electric motors to 2.25% on valves and penstocks of steel. As the break-up of costs was not available in adequate detail, we have uniformly charged depreciation on mechanical and electrical part of projects at the rate of three per cent. We are assured that that would be fair all round.

V

The calculation of the net benefits of irrigation depends upon (1) the crop pattern, (2) the yield rate of crops, (3) the prices of various farm produce and (4) the cost of inputs, both before and after irrigation.

The crop patterns, both before and after irrigation, were provided to us officially.

It is difficult to estimate the existing average yield of crops grown in the areas proposed to be irrigated by the various projects without special investigations. In the absence of such studies, reliance had to be placed on the actual yield rates of various crops, as reported in the Season and Crop Reports of the States concerned. The yield rates related to the districts in which projects were located, and were averages of 3, 4 or 5 years' actual yields. In case of the projects in Maharashtra and Mysore, the years were 1950-51 to 1954-55 and in case of Andhra 1953-54 to 1956-57, in general.

As for the yield rates of various crops under irrigated conditions, the yield rates estimated by the Maharashtra Irrigation Commission have been used uniformly, except of course those crops for which the Commission did not provide any

estimates. The Commission's estimates are based on yield experience in perennial canal irrigated areas of at least 15 to 20 years standing, in the Maharashtra State. The standards of husbandry are quite high in these areas and these have been taken into account by the Commission in arriving at their estimates. They, we presume, will provide as good estimates of yield under irrigated conditions in other parts of Maharashtra, Mysore and even the areas of Andhra under discussion. Table 'A' below gives the estimates of irrigated crop yields accepted by the Maharashtra Irrigation Commission.

Table A : Maharashtra Irrigation Commission estimates of crop yield per acre under irrigated conditions.

1. Paddy	20 Bengal mds.
2. Kharif Jowar	15 " "
3. Rabi Jowar	15 " "
4. Bajri	12 " "
5. Wheat	15 " "
6. Gram	12 " "
7. Tur	10 " "
8. Groundnut (pods)	25 " "
9. Ordinary cotton (Kapas)	10 " "
10. Long staple cotton (")	20 " "
11. Sugarcane	35 tons

A word about the estimated yields of rice (or paddy) in Andhra. Season and Crop Reports for Andhra show that an overwhelming proportion (more than 90%) of the paddy grown in the State is irrigated, and that too mainly by canals. The existing yield rates are therefore irrigated yield rates. Naturally introduction

of newer irrigation will not affect these yield rates very much; it would only extend rice cultivation over a much larger area than at present. This is seen in our Nagarjuna Sagar estimates. We have of course made a slight upward revision of the rice yield estimates: from 12 mds. under existing conditions (mostly irrigated) to 14 mds. after the Project comes into being.

The prices of different crops are the Farm (Harvest) Prices for the year 1958-59. Where these prices were not available, similar prices in neighbouring districts, and the wholesale price of the commodity in the district in that year have been taken. As in the case of yields, it would have been better to use a 5 or 10 yearly average price instead of the prices of a particular year with all its shortcomings. This has, however, not been possible in the short time at our disposal.

The more difficult estimate is that of costs, since these might vary from region to region, depending upon the type of farming. In the absence of detailed farm management data (under both non-irrigated and irrigated conditions) it is not possible to make appropriate estimates of these. Therefore, the farm management data available at the Institute were used to estimate seed, manure and fertilizer expenses for different crops, as well as fodder expenses on farms. These rates, expressed either in terms of rupees per acre or as a proportion of the gross value of produce were used in preparing farm cost estimates in all these projects. Naturally these rates, used uniformly, are rough and ready, and could be improved upon if better data become available.

Receipts of fodder on farms have been calculated on the

basis of the yield of jowar and bajra and maize. Under existing non-irrigated conditions fodder receipts are estimated to be 40% of the gross value of produce of these crops. Under irrigated conditions this proportion is taken to be 25%.

Food and fodder expenses are estimated to be 10% of the gross value of crop produce on the farms under both irrigated and non-irrigated conditions.

Farm yard manure (or cattle droppings) receipts are estimated at 30% of the expenses on food and fodder.

It is to be noted here that labour expenses have not been taken into account in calculating costs, though it is well known that these inputs are higher under irrigated than under dry conditions of farming. But this is a more complicated estimate, and without detailed data about available labour supply in the farm families and requirements of different crops, etc., it is not possible to attempt this.

VI

The benefit cost ratios for the following projects for which data were made available to us are tabulated below and detailed calculations are attached at the end.

Name of Project.	Benefit-cost ratio
1. Koyna Hydel Project (67.5 T.M.C. diversion to West)	1.17
2. Koyna Hydel Project (full diversion of 118.0 T.M.C. to West)	1.99
3. Koyna Irrigation Project	2.70
4. Bijapur Lift Irrigation Project	0.90

Name of Project	Benefit-cost ratio
5. Upper Krishna Project	
(a) With Koyna storage	0.96
(b) Without Koyna storage	1.10
6. Shri Shailam Hydro Electric Project	0.96
7. Nagarjun Sagar Project Stage I	1.16

The benefit-cost ratios speak for themselves. Except in the cases of Koyna Hydrel Project, Koyna irrigation project, one alternative of the Upper Krishna Project, and the Nagarjun Sagar Project (Stage I) they are below one in all cases. The latter projects accordingly cannot be considered sound economically. The relative productivity of alternative uses of water can be considered only in connection with former projects in whose case the benefit-cost ratios are more than one. If the productivity be judged by comparing these ratios Koyna irrigation tops the list and Koyna hydrel (full development) comes next, followed by Nagarjun Sagar Project (Stage I) and the Koyna hydrel (as now sanctioned) and the Upper Krishna projects. This would indicate that though in the immediate vicinity of the Koyna dam the use of its water for irrigation is as productive as its use for hydrogeneration by westward diversion, this is not so downstream. As compared to all uses of water further downstream, its use for hydrogeneration by westward diversion is much more productive.

Benefit-cost ratios of projects are, however, comparable with one another for economically ranking them only if the scale of projects being compared is roughly similar. In the projects

compared in this note the scale of investment roughly ranges between Rs. 27 crores to Rs. 139 crores. We have to resort to another statistical device to overcome these dissimilarities of scales of different projects. In such cases it is desirable to calculate for each project the internal rate of return and to compare these rates to decide the relative productivity of all projects.¹ The formula used for calculating this rate is :

$$\text{Investment} = \left\{ \frac{1 + \frac{1}{(1+i)^n}}{i} \right\} \times A$$

where A = Annual return = annual benefits - operating costs.

n = The number of years over which you get A returns and the investment works itself off.

i = Internal rate of return.

But even to apply this formula the benefit-cost ratios to be compared have to exceed 1.0. If they do not, then the annual return is negative and the internal rate of return also becomes negative. In the following table we have calculated the internal rates of return for all projects considered here that have benefit-cost ratios greater than 1.0 after assuming 100 years life for each of the projects. When these are compared the very high economic productivity of the waters of the Koyna for the generation of electricity by Westward diversion compared to that of using them for irrigation in the east, except in the immediate vicinity of the Koyna dam, stands out quite clearly. It also brings out the fact that the Koyna hydro project as

¹ Roland N. Mckean, Efficiency in Government through Systems Analysis, with emphasis on Water Resource Development, New York, Wiley and Sons, 1958, pp. 120-123.

	Benefit-cost ratio	Rate of return %
1. Koyna Hydrel Project.		
(a) 67.5 T.M.C. diversion to West	1.17	5
(b) 118.0 T.M.C. diversion to West	1.99	17.5
2. Koyna Irrigation Project	2.7	19.5
3. Upper Krishna Project (Storages at Almatti and Narayanpur)	1.10	2.5
4. Nagarjun Sagar - Stage I	1.16	2.5

sanctioned at present (67.5 T.M.C. westward diversion) is economically not the best choice. As sanctioned now it makes an inadequate and relatively wasteful use of available resources. The proper course now is to go ahead with the fullest development of the hydrel project.

~~~~~  
VV  
VV  
VV DETAILED CALCULATIONS FOR BENEFIT COST RATIOS VV  
VV FOR DIFFERENT PROJECTS. VV  
VV  
VV  
VV  
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The Koyna Hydel Project

(Westward diversion of 67.5 T.H.C.)

	<u>Crores of Rs.</u>
(a) <u>Investment</u> (Cost of Construction)	
(i) Storage dam on Koyna	14.30
(ii) Electrical part and installations	23.06
(iii) Cost of installations at the foot of the dam for generating power by eastward flow	2.175
(iv) Tailrace power station	15.00
(v) Transmission line from Koyna to Bombay including sub-stations	11.33
Total:	----- 65.865 or 66.00
(b) <u>Annual Costs</u>	<u>Lakhs of Rs.</u>
(i) Interest charges on the capital investment of Rs.66 crores @ 10%	660.00
(ii) Depreciation @ 1% on storage dam (Rs. 14.30 crores)	14.30
@ 3% on the remaining (Rs.51.70 crores)	155.10
(iii) Maintenance etc. @ 1.5% on all investment (Rs. 66 crores)	99.00
Total:	----- 928.40
(c) <u>Annual benefits</u>	
Power generated by westward diversion (2150 million kwh).	Proceeds of sale of power after allow- ing for 10% trans- mission losses @ 4.5 nP. per kwh.
	<u>Lakhs of Rs.</u>
Plus tail race (450 million kwh).	
Plus foot of the dam (80 million kwh).	
Equal to 2680 million kwh.	1,089.00
(d) Benefit-cost ratio	
[(c) / (b)]	1.17

The Koyna Hydel Project

(Westward diversion 118 T. M. C.)

	<u>Crores of Rs.</u>
(a) <u>Investment</u> (Cost of Construction)	
(i) Storage dam on Koyna	20.00
(ii) Electrical parts & installations	23.06
(iii) Tailrace power station	15.00
(iv) Transmission lines Koyna-Bombay	11.33

Total:	69.39 or 70.00 -----

	<u>Lakhs of Rs.</u>
(b) <u>Annual Costs</u>	
(i) Interest charges @ 10% on capital investment of Rs. 70 crores	700.00
(ii) Depreciation	
@ 1% on storage dam (Rs. 20 crores)	20.00
@ 3% on the remaining (50 crores of rupees)	150.00
(iii) Maintenance etc., @ 1.5% on total investment	105.00

Total:	975.00

(c) <u>Annual Benefits</u>	
Power generated by westward flow (3750 million kwh)	Proceeds of sale of power (after allowing for 10% transmission losses) at 4.5 nP. per kwh.
Plus Tail race (780 million kwh)	
	<u>Lakhs of Rs.</u>
Equal to 4530 million kwh	1,948.50
(d) Benefit-cost ratio	
[(c) / (b)]	1.99

The Koyna Irrigation Project

Lakhs of Rs.

(a)	<u>Investment</u> (Cost of construction)	
(i)	Cost of additional storage at Helwak for irrigation on prorata basis	420.00
(ii)	Cost of Electrical installation at the foot of the dam 27,500 kwh and pumps at Varunji Weir	150.00
(iii)	Transmission line from Koyna to Sholapur	206.00
(iv)	Cost of irrigation works	1270.00
	Total:	2046.00
(b)	<u>Annual costs</u>	
(i)	Interest on capital at 10% (Rs. 2046 lakhs)	204.60
(ii)	Depreciation on civil works at 1% (Rs. 1690 lakhs)	16.90
(iii)	Depreciation on electrical installations and pumps at 3% (Rs. 356 lakhs)	10.68
(iv)	Cost of power for lifting water (37.5 m.kwh at 4.5 NP. per kwh)	16.90
(v)	Administrative etc. charges on irrigated area (2,55,000 acres) at Rs. 5/- per acre	12.75
	Total:	261.83
(c)	<u>Annual benefits</u>	
(i)	Net addition to agricultural production	649.62
(ii)	Proceeds of sale of power generated at the foot of the dam (144.3 m.kwh) at 4.5 NP. per kwh	64.60
	Total:	714.22
(d)	Benefit cost ratio	
	[(c) / (b)]	2.7

Koyna Irrigation Project
Culturable Commanded Area

Satara	29,900 acres
Sangli	160,600 acres
Kolhapur	12,600 acres
Total:	203,100 acres

Existing cropping	Area in acres		Yield per	Total Yield	Price	Total Value in Rupees
1 Sugarcane (& others)	5,900	x	25 tons =	1,47,500 tons x	Rs.50/- =	7,375,000.00
<u>Kharif</u>						
2 Jowar	40,600	x	424 lbs. =	2,15,180 mds. x	Rs.12/- =	2,582,160.00
3 Paddy	4,800	x	1100 lbs. =	66,000 " x	Rs.15/- =	990,000.00
4 Groundnut	42,300	x	900 lbs. =	4,75,875 " x	Rs.19.5 =	9,279,562.50
5 Others	3,300	x	220 lbs. =	49,500 " x	Rs.16/- =	792,000.00
6 Pulses (gram)	14,700	x				
<u>Rabi</u>						
7 Jowar	60,500	x	300 lbs. =	2,26,875 " x	Rs.12/- =	2,722,500.00
8 Wheat	6,400	x	280 lbs. =	22,400 " x	Rs.20/- =	448,000.00
9 Pulses (gram)	14,800	x	220 lbs. =	40,700 " x	Rs.16/- =	651,200.00
<u>Hot Weather</u>						
10 Drugs (tobacco)	5,900	x	400 lbs. =	29,500 " x	Rs.60/- =	1,770,000.00
11 Others	4,200	x	220 lbs. =	11,550 " x	Rs.16/- =	184,800.00
						26,795,222.50
+ Add fodder 40% of Value of Jowar & Bajra						2,121,864.00
+ Dung 30% of value of fodder expense						803,856.67
						<u>29,720,943.17</u>

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	Material Expenses	Seed	Manure	Total
1	Sugarcane	368,750.00 (5%)	1,843,750.00 (25%)	2,212,500.00
2	Jowar (Kh)	51,643.20 (2%)	40,600.00 (Re.1)*	92,243.20
3	Paddy	69,300.00 (7%)	96,000.00 (Rs.20 per acre)	165,300.00
4	Groundnut	463,978.12 (5%)	1,269.00 (Re.03)*	465,247.12
5	Others	31,680.00 (4%)	18,000.00 (Re. 1)*	49,680.00
6	Pulses			
7	Jowar (R)	54,450.00 (2%)	60,500.00 (Re. 1)*	114,950.00
8	Wheat	26,880.00 (6%)	12,800.00 (Rs. 2 per acre)	39,680.00
9	Pulses	16,720.00 (2%)	19,000.00 (Re. 1)*	35,720.00
10	Others			
11	Drugs	123,900.00 (7%)	212,400.00 (12%)	336,300.00
		<u>1,207,301.32</u>	<u>2,304,319.00</u>	
	Total expenditure on seed & manure ...			3,511,620.32
	+ Fodder expense 10% gross value of Produce ...			<u>2,679,522.25</u>
				<u>6,191,142.57</u>

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* Expenses per acre

Proposed	Acres	Yield per acre	Total yield	Price per Unit	Total value = in Rupees
<u>Perennials</u>					
1	Sugarcane	20,300 x 35 tons	= 710,500 tons	x Rs.50 per tons	= 32,505,000
<u>Two Seasonals</u>					
2	Onions	17,500 x 105 mds.	= 1,837,500 mds.	x Rs. 4 per md.	= 7,350,000
<u>Kharif</u>					
3	Paddy	32,500 x 20 mds.	= 650,000 mds.	x Rs.15 per md.	= 9,750,000
4	Jowar (Groundnut)	71,800 x 15 mds.	= 1,077,000 mds.	x Rs.12 per md.	= 12,924,000
5	L.S.Cotton	61,000 x 20 mds.	= 1,220,000 "	x Rs.32 per md.	= 39,040,000
6	Groundnut on Kharif seasonal	19,400 x 25 mds.	= 485,000 "	x Rs.16 per md.	= 7,760,000
7	Gram on Paddy	32,500 x 12 mds.	= 390,000 "	x Rs.15 per md.	= 5,850,000
					118,199,000
Fodder yield 25% of the value of Jowar ...					3,231,000
Dung receipts 30% of fodder expense ...					3,545,970
					<u>124,975,970</u>

Costs in Rs.	Seed	Manure	Total value in Rupees
1 Sugarcane	1,776,259 (5%)	8,881,250 (25%)	10,657,500
2 Onions	875,000 (Rs. 50 per acre)	875,000 (Rs. 50 per acre)	1,750,000
3 Paddy	682,500 (7%)	1,300,000 (Rs. 40 per acre)	1,982,500
4 Jowar	258,480 (2%)	2,872,000 (Rs. 40 per acre)	3,130,480
5 L.S.Cotton	2,342,400 (6%)	3,660,000 (Rs. 60 per acre)	6,002,400
6 Groundnut	388,000 (5%)	194,000 (Rs. 10 per acre)	582,000
7 Gram	234,000 (4%)	325,000 (Rs. 10 per acre)	559,000
	6,556,630	18,107,250	24,663,880
Fodder expense 10% of gross value of produce	1,819,900
			<u>36,483,780</u>
Net Benefits: 124,975,970 - 36,483,780 = Rs. 88,492,190/-			

Bijapur Lift Irrigation Scheme in Mysore State

(a) <u>Investment</u> (cost of Construction)	<u>Crores of Rs.</u>
(i) Storage on Koyna at Helwak (gross capacity 75 TMC)	17.40
(ii) Cost of pickup weirs at 4 places (Ainapur, Halial, Hirepadsalgi, Chimalgi)	1.09
(iii) Cost of civil works for pumping installations etc.	2.94
(iv) Cost of canals and distribution system	37.62
(v) Transmission lines to Hirepadsalgi	
a) From Kali Nadi (128 miles long double circuit, 0.35 sq. inches of equivalent Copper)	Rs.3.7 Cro- res
b) From Koyna dam (127 miles long double circuit 0.2 sq. inches of equivalent Copper)	Rs.1.68 "
Total:	5.38 "
(vi) Electrical installations, power stations etc.	
i) Additional sub-stations & power lines from Hirepadsalgi to various lift sites	0.37
ii) Cost of pumps	8.23
iii) Cost of raising mains valves	13.87
iv) Electric Installation /etc. at the foot of Koyna dam	2.60
Total:	25.07
(b) <u>Annual Costs</u>	<u>Lakhs of Rs.</u>
(i) Interest charges	@ 10% 900.00
(ii) Depreciation @ 1% on civil works (Rs. 59.05 crores)	59.05
@ 3% on electric installations (Rs. 30.45 crores)	91.35
(iii) Maintenance and administration of canals & irrigated area of 540,000 acres at Rs. 5/- per acre	27.00
(iv) Cost of power required for working the pumps etc. 923 million kWh @ 4.5 nP. per kwh at bus bars at Kalinadi power house & Koyna dam Power House	1077.40
Total:	415.35 1492.75
(c) <u>Annual benefits</u>	
(i) Net increase in agricultural production due to irrigation (as per statement)	1198.15
(ii) Sale of power generated at the /attached foot of the Koyna dam (308 million kwh) @ 4.5 nP. per kwh.	138.60
Total:	1336.75
(d) Benefit-cost ratio [(c) / (b)]	0.90

Bijapur Lift Irrigation Scheme

(area : 540,000 acres)

Existing Crop pattern & agricultural production

Area	Per acre yield	Total yield	Price Rs. per maund	Value of production Rs.
<u>Kharif</u>				
Jowar	108,000 x 264 lbs.	= 356,400	x 12	= 4,276,800.00
Groundnut	65,000 x 966 lbs.	= 784,875	x 19.5	= 15,305,062.50
Bajri	70,000 x 151 lbs.	= 132,125	x 10	= 1,321,250.00
<u>Rabi</u>				
Jowar	119,000 x 274 lbs.	= 407,575	x 14	= 5,706,050.00
Cotton	75,500 x 38 lbs.	= 358,625	x 28	= 1,004,150.00
Wheat	32,500 x 173 lbs.	= 70,261.25	x 20	= 1,405,625.00
Pulses	70,000 x 250 lbs.	= 218,750	x 16	= 3,500,000.00
540,000		2,005,868.75 maunds		32,516,937.50
		Add fodder 40% of Jowar		3,993,140.00
		Add Dung		1,463,352.00
				<u>37,975,429.50</u>
<u>Expenses</u>				
	Seed		Manure	Total in Rs.
Kh. Jowar	85,536 (2%)	108,000 (Rs.1 per acre)		193,536
Groundnut	765,253.1 (5%)	1,950 (.03 Rs per acre)		767,203
Bajri	26,425 (2%)	17,500 (.25 ")		43,925
Rabi Jowar	114,121 (2%)	95,200 (.8 ")		209,321
Cotton	100,415 (10%)	166,100 (Rs.2.2 per acre)		266,515
Wheat	140,562.50 (10%)	65,000 (Rs.2 per acre)		205,562.50
Pulses	140,000 (4%)	70,000 (Rs.1 per acre)		210,000
				<u>1,396,062</u>
		Fodder expense 15% of gross value of produce		4,677,840
				<u>6,773,902</u>
Net Rs.	3,79,75,429.5	- Rs. 67,73,902.0		= Rs.31,201,527.5

Bijapur Lift Irrigation SchemeProposed Crop Pattern

	Area in acres	Yield per acre	Total yield	Price	Total value in Rupees
Sugarcane	54,000	35 tons	1,890,000	Rs.50 per ton	94,500,000
Paddy	1,19,000	20 mds.	2,380,000	Rs.15 per maund	35,700,000
Kh. Jowar	2,32,000	15 mds.	3,480,000	Rs.12 per maund	41,760,000
Rabi Jowar	61,000	15 mds.	1,215,000	Rs.12 per maund	14,580,000
Rabi Cotton	27,000	10 mds.	270,000	Rs.32 per maund	8,640,000
Rabi Wheat	27,000	15 mds.	405,000	Rs.20 per maund	8,100,000
					203,280,000
		+ Fodder (25% of Jowar production)			14,085,000
		+ Dung (30% of fodder expenses)			6,074,400
					<u>223,439,400</u>
<u>Expenses</u>	<u>Seed</u>	<u>Manure</u>			
Sugarcane	4,725,000 (5%)	23,625,000 (25%)			28,350,000
Paddy	2,443,000 (7%)	4,760,000 (Rs.40 per acre)			7,203,000
Kh. Jowar	835,200 (2%)	9,260,000 (Rs.40 ")			10,115,200
Rabi Jowar	291,600 (2%)	3,240,000 (Rs.40 ")			3,531,600
Cotton	510,400 (6%)	810,000 (Rs.30 ")			1,320,400
Wheat	486,000 (6%)	1,080,000 (Rs.40 ")			1,566,000
					52,094,200
		Add 10% of gross produce (fodder charges)			20,328,000
					<u>72,422,200</u>
Net Rs. 223,439,400	-	Rs. 72,422,200			
	=	<u>Rs.151,017,200</u>			<u>151,017,200</u>

Upper Krishna Project

With storage on Koyna at Helwak and diversion works at Almatti and Narayanpur in Mysore State.

	<u>Crores of Rs.</u>
(a) <u>Investment</u> (Cost of construction)	
(i) storage on Koyna at Helwak of 77.2 mC (gross)	17.80
(ii) Cost of electric installations at the foot of the Koyna dam 4 units x 8000 kwh	1.40
(iii) Transmission line from Koyna dam to Sholapur 145 miles	2.06 <u>3.46</u> 3.46
(iv) Cost of diversion works at Almatti and Narayanpur with cost of canals, etc.	57.04
	Total: <u>78.30</u> -----
(b) <u>Annual Costs</u>	Lakhs of Rs. @ 10%
(i) Interest charges	783.00
(ii) Depreciation @ 1% on civil works (Rs. 74.84 crores)	74.84
Depreciation @ 3% on electrical installations (Rs. 3.46 crores)	10.38
(iii) Administrative and maintenance charges at Rs. 5 per acre (area irrigated 545,000 acres)	27.25
	Total: <u>895.47</u> -----
(c) <u>Annual benefits</u>	
(i) Net increase in agricultural production due to irrigation (as per statement attached)	833.10
(ii) Power generated at the foot of the dam 100 m.Kwh at 4.5 nP. per Kwh.	45.00
	Total: <u>878.10</u> -----
(d) <u>Benefit-cost ratio</u>	
[(c) / (b)]	0.965

Upper Krishna Project

With storage at Royna and diversion works at Alnatti Narayanpur. (Area irrigated: 5,45,000 acres)

Existing crop pattern and agricultural production

	Area acres	Per acre yield	Total pro- duction	Price per Md. Rs.	Total Value Rs.
<u>Kharif</u>					
Jowar	136,250	x 246 lbs. =	416,966.75	x 12	5,027,625
Groundnut	163,250	x 966 lbs. =	1,971,243.75	x 19.5	38,439,253.
<u>Rabi.</u>					
Cotton	136,250	x 40 lbs. =	5,450,000	x 28	1,907,500
Millets (Jowar)	109,250	x 276 lbs. =	376,912.50	x 14	5,276,775
	545,000		2,835,250.00		50,651,153.
				+ Fodder	4,121,760
				+ Dung	2,279,241
					57,052,154.

<u>Expenses</u>	<u>Seed</u>	<u>Manure</u>	<u>Total</u>
Kh. Jowar	100,552.50 (2%)	136,250 (Rs.1/acre)	236,802.50
Groundnut	1,921,962.66 (5%)	4,897.50 (.03 Rs./ acre)	1,926,860.16
Cotton	190,750 (10%)	299,750 (Rs.2.2/acre)	490,500
Rabi Jowar (Millets)	105,535.50 (2%)	87,400 (Rs.8/acre)	192,935.50
			2,847,098.16
		+ Fodder	7,597,672.00
			10,444,770.16

Net Rs. 57,052,154.12 - Rs. 10,444,770.16 = Rs. 46,607,384.00

Proposed Upper Krishna Project

With storage at Almatti and Narayanpur etc.

	Area in acres	Per acre yield	Total yield in maunds	Price/ Rs.	Total value in Rupees
Sugarcane	27,000	35 tons	945,000 tons	50 per ton	= 47,250,000
Light perennials	11,000	Rs. 800			= 8,800,000
Two Seasonals Onions	27,200	x 105 mds.	= 2,856,000	x 4	= 11,424,000
Paddy	97,000	x 20 mds.	= 1,940,000	x 15	= 29,100,000
Kharif Seasonal (Jowar)	1,36,800	x 15 mds.	= 2,052,200	x 12	= 24,624,000
Rabi (Jowar)	2,46,000	x 15 mds.	= 3,690,000	x 12	= 44,280,000

					165,478,000
				+ Fodder	17,226,000
				+ Dung	4,964,340

					187,668,340

<u>Expenses</u>					
		<u>Seed</u>		<u>Manure</u>	
Sugarcane	2,362,500	(5%)	11,812,500	(25%)	= 14,175,000
Light perennials	11,000 acres	150 per acre			= 1,650,000
Two Seasonals Onions	1,360,000	(50 Rs./acre)	1,360,000	(Rs. 50/acre)	= 2,720,000
Paddy	2,037,000	(7%)	3,880,000	(Rs. 40/acre)	= 5,917,000
Kharif Seasonal (Jowar)	492,480	(2%)	5,472,000	(Rs. 40/acre)	= 5,964,480
Rabi (Jowar)	885,600	(2%)	9,480,000	(Rs. 40/acre)	= 10,725,600

				Add Fodder expenses	41,202,080
					16,547,800

					57,749,880

Net Rs. 187,668,340	-	Rs. 57,749,880	=	Rs. 129,918,460	
Net increase in agricultural produce				Rs. 129,918,460	
				-	Rs. 46,607,384

			Net	Rs. 83,311,076	

Upper Krishna Project

Storage and diversion works at Almatti and Narayanpur only

Crores of Rs.(a) Investment (Cost of construction)

- (i) Cost of storages at Almatti and Narayanpur with costs of canals for irrigating 608,000 acres

73.80

Lakhs of Rs.
@ 10%(b) Annual costs

- (i) Interest charges

738.00

- (ii) Depreciation at 1%

73.80

- (iii) Maintenance and administration etc. of 608,000 acres at Rs. 5 per acre

30.40

Total: 842.20(c) Annual benefits

- (i) Net increase in agricultural production due to irrigation (as per statement attached)

934.46

(d) Benefit-cost ratio

[(c) / (b)]

1.10

Upper Krishna Project

Storages at Almatti and Narayanpur only

To Koyna Storage: Storage and diversion works at Almatti and Narayanpur. (Area irrigated 608,000 acres)
Existing crop pattern and production

	Area acres	Per acre yield	Total produc- tion	Price/ maund in Rs.	Total value Rs.
<u>Kharif</u>					
Jowar	152,000	x 246 lbs. =	467,400	x 12 =	5,608,800
Groundnut	182,000	x 966 lbs. =	2,197,650	x 19.5 =	42,954,175
<u>Rabi</u>					
Cotton	152,000	x 40 lbs. =	76,000	x 28 =	2,128,000
Millets	122,000	x 276 lbs. =	420,900	x 14 =	5,892,600
	608,000		3,161,950		56,483,575
				Add Fodder	4,600,560
				Add Dung	2,541,760
					63,625,895
<u>Expenses</u>					
	<u>Seed</u>		<u>Manure</u>		<u>Total</u>
Kharif Jowar	112,176 (2%)		152,000 (Rs.1/acre) =		264,176
Groundnut	2,142,708 (5%)		5,460 (.03 Rs./acre) =		2,148,168
Cotton	212,800 (10%)		334,400 (Rs.2.2/acre) =		547,200
Rabi Jowar	117,852 (2%)		97,600 (Rs.0.8/acre) =		215,452
					3,174,996
				Add Fodder	8,472,535
					11,647,531
Net Rs. 63,625,895 - Rs. 11,647,531 = Rs. 51,978,364					

	Area in acres	Yield acre	Total yield in maunds	Price Rs./ maund	Total value Rs.
<u>Proposed</u>					
Sugarcane	30,500	x 35 tons		50/ton =	53,375,000
Light perennials	12,000	x Rs. 800		=	9,600,000
Two Seasonals (Onions)	30,500	x 105 mds. =	3,202,500	x 4 =	12,810,000
Paddy	108,000	x 20 mds. =	2,160,000	x 15 =	32,400,000
Kharif Seasonals (Jowar, etc.)	153,000	x 15 mds. =	2,295,000	x 12 =	27,540,000
Rabi Jowar	274,000	x 15 mds. =	4,110,000	x 12 =	49,320,000
					<u>185,245,000</u>
<u>Expenses</u>					
		<u>Seed</u>		<u>Manure</u>	<u>Total</u>
Sugarcane	2,668,750	(5%)	13,343,750	(25%) =	16,012,500
Light Perennials	Rs. 150	per acre		=	1,800,000
Two Seasonals (Onions)	1,525,000	(Rs. 50/ acre)	1,525,000	(Rs. 50/ acre) =	3,050,000
Paddy	2,268,000	(7%)	4,320,000	(Rs. 40/ acre) =	6,588,000
Kharif (Jowar etc.)	550,800	(2%)	6,120,000	(Rs. 40/ acre) =	6,670,800
Rabi Jowar	986,400	(2%)	10,960,000	(Rs. 40/ acre) =	11,946,400
					<u>46,067,700</u>
<u>Receipts</u>					
Crop (Total)					185,245,000
Add Fodder					19,215,000
Add Dung					5,557,350
					<u>210,017,350</u>
<u>Expenses</u>					
Seed + manure, etc.					46,067,700
Fodder					16,524,500
					<u>64,592,200</u>
Net Rs. 210,017,350		-	Rs. 64,592,200	=	Rs. 145,425,150
Net increase in agricultural production					
Rs. 145,425,150		-	Rs. 51,976,364	=	Rs. 93,446,780

Shri. Shailam Project

	<u>Lakhs of Rs.</u>
(a) <u>Total cost of the Project</u>	
(i) Civil works	2,345.0
(ii) Electrical Equipment	692.0

	Total: 3,037.0
(b) <u>Annual costs</u>	
(i) Interest 10% on capital (Rs. 3037.0 lakhs)	303.70
(ii) Depreciation on civil works at 1%	23.45
(iii) Depreciation at 3% on electrical installations	20.76
(iv) Maintenance, administration etc. at 1-1/2 % on capital	35.16

	383.07
(c) <u>Annual Benefits</u>	
Total generation: 1367 m Kwh at 2.7 nP. per Kwh	369.10
(d) <u>Benefit-cost ratio</u>	
[(c) / (b)]	0.96

Nagarjun Sagar Project

	<u>Lakhs of Rs.</u>
(a) Cost of the Project	13,953
(b) <u>Annual Costs</u>	
(1) Interest at 10%	1,395.30
(2) Depreciation 1%	139.53
(3) Administration, maintenance etc. Rs. 5 per acre (20 lakh acres)	100.00

	1,634.83
(c) <u>Annual benefits</u>	
Net addition to agricultural production	1,890.00
(d) <u>Benefit Cost Ratio</u>	
[(c) / (b)]	1.16

Nagarjun Sagar Project: Existing crop pattern and Agricultural Production.

	Crop	Guntur	Nellore	Kurnool	Nalgonda	Khammam	Krishna	Total
	<u>Rice</u>							
1	Area in acres	25740	77300	1800	18120	26730	19320	
2	Yield per acre in mds.	17.30	16.25	11.14	10.54	10.39	14.45	
3	Total yield in mds.	445302.0	1256125.0	20052.0	190984.8	277724.7	279174.0	
4	Price per md. in Rs.	21.00	23.21	23.68	25.00	25.00	21.8	
5	Value of pro- duct in Rs.	9351342	29154661	474831	4774620	6943117	6085993	56784564
	<u>Cholam</u>							
1	Area in acres	360360	77300	-	21140	32670	143520	
2	Yield per acre in mds.	7.25	5.70	-	2.54	4.92	5.52	
3	Total yield in mds.	2612610.0	440610.0	-	53695.6	160736.4	792230.4	
4	Price per md. in Rs.	13.26	12.72	-	11.81	14.19	13.42	
5	Value of pro- duct in Rs.	34643208	5604559	-	634145	2280849	10631732	53794493
	<u>Sajja</u>							
1	Area in acres	115830	69570	2100	39260	-	5520	
2	Yield per acre in mds.	4.06	11.87	6.94	6.94	-	5.30	
3	Total yield in mds.	470269.8	825795.9	14574.00	272464.4	-	29256.0	
4	Price per md. in Rs.	14.46	14.20	11.77	11.54	-	12.10	
5	Value of pro- duct in Rs.	6800101	11726302	171536	3144239	-	353998	22196176

Crop	Guntur	Nellore	Kurnool	Nalgonda	Khammam	Krishna	Total
<u>Groundnut</u>							
1 Area in acres	115830	-	-	45300	32670	44160	
2 Yield per acre							
in mds.	12.70	-	-	5.56	6.60	12.67	
3 Total yield							
in mds.	1471041.0	-	-	251868.0	215622.0	559507.2	
4 Price per md.							
in Rs.	17.00	-	-	17.18	17.18	17.62	
5 Value of product							
in Rs.	25007697	-	-	4327092	3704386	9858517	42897692
<u>Korra</u>							
1 Area in acres	-	-	8100	-	-	-	
2 Yield per acre							
in mds.	-	-	3.70	-	-	-	
3 Total yield in mds.	-	-	29970.0	-	-	-	
4 Price per md.in Rs.	-	-	10.27	-	-	-	
5 Value of product							
in Rs.	-	-	307792	-	-	-	307792
<u>Samai</u>							
1 Area in acres	-	-	2400	-	-	-	
2 Yield per acre in							
mds.	-	-	4.35	-	-	-	
3 Total yield in mds.	-	-	10440.0	-	-	-	
4 Price per md.in Rs.	-	-	7.00	-	-	-	
5 Value of product							
in rupees	-	-	73080	-	-	-	73080
<u>Castor</u>							
1 Area in acres	-	-	2400	24160	-	-	
2 Yield per acre in mds.							
in mds.	-	-	1.81	1.79	-	-	
3 Total yield in mds.	-	-	4344.0	43246.4	-	-	
4 Price per md.in Rs.	-	-	14.81	19.33	-	-	
5 Value of product							
in Rs.	-	-	643355	835953	-	-	900288

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Contd....

Crop	Guntur	Nellore	Kurnool	Nalgonda	Khammam	Krishna	Total
<u>Green Gram & Others</u>							
1 Area in acres	115830	162330	1800	39260	74250	46920	
2 Yield per acre in mds.	2.15	3.37	3.31	3.84	1.87	3.51	
3 Total yield in mds.	249034.5	547052.1	5958.00	150758.4	138847.5	164689.2	
4 Price per md.in Rs.	18.78	21.00	18.61	15.00	15.00	18.25	
5 Value of product in Rs.	4676868	11488094	111176	2261376	208712	3005578	23625804
<u>Ragi</u>							
1 Area in acres	-	-	1800	-	-	-	
2 Yield per acre in mds.	-	-	12.13	-	-	-	
3 Total yield in mds.	-	-	21816.0	-	-	-	
4 Price per md.in Rs.	-	-	13.15	-	-	-	
5 Value of product in Rs.	-	-	286880	-	-	-	286880
<u>Rice</u>							
1 Area in acres	-	23190	300	18120	-	-	
2 Yield per acre in mds.	-	16.25	11.11	10.54	-	-	
3 Total yield in mds.	-	376837.5	3342.0	19098.8	-	-	
4 Price per md.in Rs.	-	23.21	23.68	25.00	-	-	
5 Value of product in Rs.	-	8746398	79139	4774620	-	-	13600157
<u>Cotton</u>							
1 Area in acres	12870	23190	2100	3020	-	-	
2 Yield per acre in mds.	0.89	0.62	0.62	0.52	-	-	
3 Total yield in mds.	11454.3	14377.8	1302.0	1570.4	-	-	
4 Price per md. in Rs.	22.04	22.04	22.04	22.04	-	-	
5 Value of product in Rs.	252453	316887	28696	34612	-	-	632648

Crop	Guntur	Nellore	Kurnool	Nalgonda	Khammam	Krishna	Total
<u>Tobacco</u>							
1 Area in acres	141570	-	-	-	-	-	
2 Yield per acre in mds.	8.64	-	-	-	-	-	
3 Total yield in mds.	123024.3	-	-	-	-	-	
4 Price per md. in Rs.	60.00	-	-	-	-	-	
5 Value of product in Rs.	7381458	-	-	-	-	-	7381458
<u>Cholam</u>							
1 Area in acres	-	162330	2700	48320	112860	-	
2 Yield per acre in mds.	-	5.70	6.14	2.54	4.92	-	
3 Total yield in mds.	-	925281.0	16578.0	122732.8	555271.2	-	
4 Price per md. in Rs.	-	12.72	12.23	11.81	14.19	-	
5 Value of product in Rs.	-	11769574	207749	1449474	7879298	-	21301095
<u>Yavalu</u>							
1 Area in acres	-	61840	2100	-	-	-	
2 Yield per acre in mds.	-	5.00	5.00	-	-	-	
3 Total yield in mds.	-	309200.0	10500.0	-	-	-	
4 Price per md. in Rs.	-	14.50	5.00	-	-	-	
5 Value of product in Rs.	-	4483400	52500	-	-	-	4535900
<u>Gram & Others</u>							
1 Area in acres	386100	92760	2400	45300	5940	16560	
2 Yield per acre in mds.	5.62	5.62	5.36	5.62	5.62	5.74	
3 Total yield in mds.	2169882.0	521311.2	12864.0	2545868.0	33382.8	95054.4	
4 Price per md. in Rs.	9.11	9.11	9.11	9.11	9.11	9.11	
5 Value of product in Rs.	19767625	4749145	117791	2319278	304117	865946	28123902
<u>Total</u>							
1 Area							
2 Yield per acre							
3 Total yield in mds.							
4 Price per md.							
5 Value of product in rupees	107880752	88039020	1970505	24555409	23194479	30801764	276441929

Expenditure

	Seed		Manure		Total value in Rupees	
1	Rice	4,926,930	7%	5,265,500	Rs.25/-	10,192,430
2	Jowar (Cholam)	1,501,912	2%	961,200	Re. 1/-	2,463,112
3	Bajara	443,924	2%	110,981	0.5%	554,905
4	Groundnut	2,144,685	5%	237,960	Re. 1/-	2,382,845
5	Korra	6,156	2%	-	-	6,156
6	Samai	1,462	2%	-	-	1,462
7	Varagu	90,718	2%	-	-	90,718
8	Castor	18,006	2%	26,560	Re. 1/-	44,566
9	Green gram and others	945,032	4%	440,390	Re. 1/-	1,385,422
10	Cotton	632,65	10%	82,360	Rs. 2/-	145,625
11	Tobacco	516,702	7%	885,775	12%	1,402,477
12	Gram and others	1,124,956	4%	634,760	Rs.2/-	1,759,716
13	Ragi	11,475	4%	1,800	Re.1/-	13,275
	Total	11,795,423		8,647,286		20,442,709

Present Pattern (For 29 lakh acres)

Value of production.	Rs.	
	276,441,929	Gross produce
	38,916,706	Fodder (i.e. 40% of Jowar & Bajra)
	8,293,258	Dung (30% of Fodder expenses)
	323,651,893	
Expenditure	20,442,709	Seed and Manure
	27,644,193	Fodder expenses (i.e. 10% gross produce)
	48,086,902	
Net Production	275,564,991	For 29 lakh acres.
Pro rata	190,029,618	For 20 lakh acres.

Nagarjun Sagar Project

Proposed crop pattern and production

	Area	Yield per acre in maunds	Price per maund Rs.	Value in Rupees
Rice	1,042,100	x 14	23.28	= 339,641,232
Others (Jowar, Bajra Cotton, Groundnut)	957,900	x Rs.205*		= 196,309,500
				<u>536,010,732</u>

* Average value of produce per acre of the four crops Jowar, Bajra, groundnut and cotton with equal weightage.

Fodder receipts (25% of Jowar, Bajra). 24,546,187

Dung receipts 30% of fodder expenses 16,080,321

40,626,508

576,637,240

Expenses

	Seed	Manure	
Rice	23,774,886 (7%)	41,684,000 (Rs.40 per acre)	65,458,886
Others	9,810,475 (5%)	68,729,315 (35%)	78,547,790
			<u>144,006,676</u>
Fodder expenses 10% of gross value of produce			53,601,073
			<u>197,607,749</u>
Net production			379,029,491
Existing Net Production			190,029,618
Addition to Net Production			<u>188,999,873</u>

A comparative economic study of the alternative uses of water of Krishna in the Ghat areas of Maharashtra for generation of hydro-electricity and for irrigation in Maharashtra and lower states.

The question of economic alternative use of water for generation of hydro-electric power and for irrigation particularly when high heads are available for power generation without any significant benefits of irrigation is a very much controversial issue.

The following Hydro-electric projects are proposed by the Maharashtra State wherein the waters of Krishna are proposed to be diverted to the west i.e. outside the Krishna basin for generation of hydro-power. These projects are divided into three groups each having a special characteristic of its own:

<u>Group I</u>	Proposed diversion in T.M.C.
(i) Phonda Project	12.61
(ii) Vel-holi Hydel Scheme	4.70
<u>Group II</u>	
(i) Patharpunj Project	2.74
(ii) Gothna Project	3.60
<u>Group III</u>	
(i) Koyna Hydro-electric Project Stage IV	118.00
(ii) Kadvi Project	23.97
(iii) Kasari Project	48.90
(iv) Kumbhi Project	33.91
(v) Vedganga Project	15.20
(vi) Ajra Project	30.10

Group I

This group represents projects in which entire tail-race water are proposed to be utilised fully for irrigation.

In group I, there are only two projects viz:-

(i) Velholi Hydel Scheme.

(ii) Phonda Project.

In both these schemes, the entire tail-race water ^{proposed} is/to be utilised for irrigation and for industries and water supply. Therefore, the question of non-utilisation and consequent waste of tail-race waters does not arise. The Maharashtra Government has prepared a Master Plan for utilisation of all physically harnessable water resource in the Ullhas and Patalganga Valleys in which full account of the harnessable water resource of the west flowing streams has been taken. This resource has been found to be inadequate to meet the requirements of the water supply to industries and the Greater Bombay City including the water needs of irrigation development in these valleys. The diversion of waters of Indrayani at Vel-holi is therefore, proposed for generation of power and full use of the tail-race in these two valleys. Similarly, in the case of Phonda Project the available water resource is proposed to be utilised fully for irrigation in the Ratnagiri district. The question of economic soundness and desirability of diversion of waters of the Krishna valley for both these schemes does not, therefore arise.

Group II

This group represents high load hydro-electric projects with the head of the order of 2100 to 2300 feet with utilisation of 40% tail-race waters for irrigation. In this group the head

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available is very high and the quantum of water proposed to be^{of the} diverted is very small. In addition, 40% /tail-race waters are^{also} also proposed to be utilised for drinking water, irrigation, etc. Here the benefits of power generation are very high, and the quantum of water which is not utilised for irrigation, etc. is negligibly small. Accordingly the desirability of such a diversion needs no further justification.

Group III

In this group, there are 6 schemes in which storages are proposed on the tributaries of Krishna for diversion of waters to west for power generation. This natural water resource has two alternative uses :-

- (i) for hydro-electric power generation as proposed by the Maharashtra State, and
- (ii) irrigation in the valley By utilisation of the water resource in the lower reaches of the Krishna river.

The relative economic merits of the two alternatives requires a critical examination. All streams on which these hydro-electric projects are proposed except Hiranyakeshi at Ajra join Krishna above Almatti in the Mysore State and consequently the use of waters of these streams can either be made for lift irrigation in the Bijapur district as proposed by the Mysore State or for irrigation from Almatti and Narayanpur storages as proposed by the Mysore State under the Upper Krishna Project.

As detailed projects are not prepared for the Hydro-electric projects listed under Group III except for Koyna Project, for a proper economic appraisal, only the alternative uses of Koyna waters for power generation and irrigation can be considered

for assessing relative economic merits of the alternative uses of these waters. As a typical case, therefore, the water potential of Koyna upto Helwak is considered for economic examination of the alternative uses of the water resource for hydro-electric generation by diversion of waters of Krishna towards Arabian Sea and for irrigation in the Krishna basin.

The following procedure is followed in carrying out the economic study of the alternative uses of the water resource of Koyna at Helwak.

(1) Hydro-electric generation of power

Detailed estimates for construction of a storage (gross capacity of 98.00 T.M.C.) on Koyna at the Koyna Dam site are already available. The cost of the dam as per these estimates works out to Rs. 2000 lakhs. This cost is, therefore, taken as the cost of storage for the hydro-electric works. Similarly, detailed estimates for the remaining works such as Intake channel, intake tower, and penstocks, generating plant, etc. for generation of 4,20,000 KW. at 91.6% load factor are also available. The cost of these items is estimated at Rs. 2124 lakhs. As the load centre for use of Koyna power would be near Bombay, in the economic appraisal of the benefits of use of Koyna waters for power generation the cost of transmission lines from Koyna Power House to Bombay estimated at Rs. 1133 Lakhs (detailed estimate is available) is added in estimating the total cost involved in utilisation of the water resource for generation of power. Detailed estimates for tail-race development are not ready, but the rough estimate indicates the cost of generation capacity of 150 MWS. at 40% load factor at Rs. 1500 lakhs.

The abstract of costs is given in Appendix I.

The Koyna hydro-electric project is sanctioned for a diversion of 67.5 T.M.C. of supplies to the west, for power generation. As a side issue, the economics of limiting the diversion of 67.5 T.M.C. on the basis of benefit cost ratio may also be studied. The abstract costs and benefits is given in Appendix I. The economic appraisal of the Koyna hydro-electric generation for a full diversion of 118.0 T.M.C. (both exclusive of lake losses) may also be studied. The abstract of costs and benefits is given in Appendix I.

Irrigation use

The Koyna dam site at Helwak is ideally suited for generation of hydro-electricity utilising the high head available on the western side. If the water potential of Koyna upto Helwak is not used for hydro-power generation its alternative use for irrigation in the valley will have to be considered.

The 75% dependable flow of Koyna upto the Helwak dam site is about 123 T.M.C. Of this flow 67.5 + 5.0 (lake losses) = 72.5 T.M.C. are already marked for hydro-power generation and lake losses at the reservoir, leaving a balance of 123-72.5 = 50.5 T.M.C. for use for irrigation. Against this available flow of 50.5 T.M.C., the Maharashtra State has proposed utilisation of about 43 T.M.C. for irrigation on the right bank of Koyna Krishna and Left Bank of Krishna under the koyna Irrigation Scheme which is included in the Third Five Year Plan.

The Koyna Irrigation Project

The land potential available in the Maharashtra State for utilisation of the Koyna waters upto Helwak is limited. With the

area available, only 44.1 T.M.C. of supply can be utilised economically for irrigation from Koyna waters in the Maharashtra State. The balance supply can not be utilised for irrigation in the State itself. Accordingly, the data in respect of cost and benefits for annual utilisation of 44.1 T.M.C. of water resource are given in appendix I.

In the lower reaches of Krishna below Maharashtra, the Mysore State has proposed two projects viz. (1) The Bijapur Lift Irrigation Scheme and (2) the Upper Krishna Project Stage I, and Stage II. In Andhra State for alternative use the following two projects may be studied. They are :-

- (1) The Sri Seilam Hydro-electric project
- and
- (2) The Nagarjunsagar Project Stage I.

All these proposals may therefore, be considered for the alternative use of Koyna waters.

(1) The Bijapur Lift Irrigation Scheme

The Bijapur Lift Irrigation scheme is proposed by the Mysore State for irrigation of 8.5 lakh acres with a lift upto 250 ft. utilising 120.2 T.M.C. annually. The State Government has proposed a storage near Bidri which has very large submergence which includes large area under the command of the Ghataprabha Left Bank canal. The proposed storage submerges most of the wide strip of very fertile lands which could be irrigated with a low lift. The Bidri storage and lift proposal (of which no details are still worked out by the Mysore State) would therefore be inappropriate for an economic study.

As the details of engineering works required for the lift irrigation scheme given by the Mysore State for the Bijapur Lift

irrigation scheme are very vague, the economic study of that proposal in that form is not possible. The Bijapur lift irrigation scheme was once considered by the then Bombay Government. It was investigated in detail and full details thereof find place in the "Report of the Koyna valley irrigation-cum-Hydro-electric project" prepared by Shri M.L.Champhekar, I.S.E., in 1949-1950. The scheme proposed by Shri Champhekar involves much less pumping cost of water as larger areas are commanded with lesser lifts. The proposals contained in Shri Champhekar's project report are, therefore, taken up for the economic study of the costs and benefits of the lift irrigation in the Bijapur district by using Koyna waters.

The costs of the various works are worked out on the basis of the data given by Shri Champhekar in his project report. These data are based on actual surveys and detailed estimates are therefore, considered very reliable. Shri Champhekar's project proposals are, however, modified to conform with the proposed crop pattern proposed by the Mysore State in its 'Bijapur Lift Irrigation Scheme' and the costs of works, pumping sets etc. estimated by Shri Champhekar have been modified to agree with modified needs of works for the proposed crop pattern given by the Mysore Government.

For lift irrigation from Krishna in Mysore State stored water will have to be obtained from the Koyna Storage at Helwak as there is no economic storage site available on the river Krishna between Koyna and the various lift sites where water from the catchment area upto Helwak can be stored more economically than at Helwak on Koyna. The storage needed at Koyna for

irrigation works out to 75.0 T.M.C. The cost of the storage has been worked out on the basis of actual rates obtained in the construction of Koyna dam.

The structures needed on the main river Krishna at the various lift sites viz. pick up weirs etc. would be the same as those provided for by Shri Champhekar. The estimated cost based on 1948-1949 rates is shown first and the cost at 1948-49 rates is raised by 25% to bring the cost to the 1960-1961 level. Shri Champhekar had provided for pumping plant including ancillary structures for pumping water appropriate for the irrigation proposed by him in the project report. The maximum discharges now required to be pumped according to the crop pattern proposed by the Mysore State are very much higher, necessitating higher pumping capacities. The cost of installation of higher pumping capacities is now estimated on the pro-rata increase basis in the pumping capacity needed with crop pattern proposed by the Mysore State. The cost of the canals, structures, etc. has also been raised suitably to take care of the higher discharges required in the irrigation canals, etc. In other words estimated cost of the irrigation system including pumping plant but excluding cost of the pick up weirs is raised suitably from the figures estimated by Shri Champhekar to account for the increased discharges now proposed to be pumped for irrigation with larger water utilisation. The cost of various pick up weirs has however, been kept the same as estimated by Shri Champhekar. This figure of estimated cost of structures, canals, etc. is all worked out on 1948-1949 rates and is indicated in terms of estimated costs with 1948-1949 prevalent rates. The costs are then raised by

25% to bring them to 1961-1962 level.

In addition to the capital cost involved in construction of storage at Helwak and nick up weirs on the main river Krishna with ancillary works, the State will have to incur recurring expenditure on pumping of water annually for the lift irrigation proposed. The power required for pumping of water annually is worked out in terms of Kilowatt hours consumed annually for lifting the water for proposed irrigation. The number of Kilowatt hours required for pumping are based on the horse power hours necessary to lift the average discharges required to be pumped for the proposed irrigation.

For this comparative economic study of the alternative use of water resource of Koyna upto Helwak, only the water resource of Koyna upto Helwak is considered as available for pumping and utilisation for irrigation.

The power required for pumping water is proposed to be obtained from the proposed Kali-nadi hydro-electric power project mentioned by the Mysore Government. With a view to take full advantage of the power potential at the foot of the dam of the Koyna storage at Helwak it is assumed that the entire power both seasonal and firm will be transmitted to Hirepadsalgi and used fully. If this power was not proposed to be utilised for pumping and was proposed for sale elsewhere it would have become necessary to limit the generation to only firm continuous power of only 32000 KWs. at 0.6 L.F. Accordingly, provision has been made for an appropriate transmission line from Koyna dam to Hirepadsalgi. The power requirements of lift irrigation are far in excess of the power generated at the foot of the dam on Koyna

at Helwak and therefore, provision for an appropriate transmission line from Kali nadi power Station to Hirepadsalgi is also made in the estimate of costs. Relative economic studies have shown that it would be more economic to convey power from Koyna to Hirepadsalgi in addition to kali nadi power than to obtain entire power need of lift irrigation from Kali nadi power Station and sell the firm power only with a transmission line to Sholapur for which, necessary provision for a transmission line upto Sholapur will be necessary.

The Irrigation

The Mysore authorities have underestimated the irrigation water requirements for the crops proposed. The water requirements have, therefore, been worked out on the standards followed in Bombay part of Maharashtra as the areas in Bijapur district are similar to those on the Deccan Canals with similar climatic and rain-fall conditions.

It is an admitted fact that certain amount of transit losses will take place in transit of water from Helwak to Pumping sites upto Chimalgi. These transit losses are estimated at 19.1 T.M.C. Of the total available flow of 123.3 T.M.C. of Koyna at Helwak 29.34 T.M.C. are lost between Helwak and the canal head as detailed below leaving a balance of 94.00 T.M.C. available for use at the canal head :-

(1) Lake losses at Koyna Storage.	3.91 T.M.C.
(2) Transit losses between Helwak and Pumping sites	19.10 T.M.C.
(3) Evaporation losses at weirs on Krishna where pumps will be installed.	<u>6.33 T.M.C.</u>
Total losses.	<u>29.34 T.M.C.</u>

With a net water resource of 94.00 T.M.C. available at pump head 5.40 lakh acres can be irrigated on the crop pattern given by the Mysore State.

The cropwise areas irrigated annually (with 75% dependability) under the proposed crop pattern is given below :-

Sugar cane	54,000
Paddy	1,19,000
Kharif Jowar	2,32,000
Rabi Jowar	81,000
Rabi Cotton	27,000
Rabi Wheat	<u>27,000</u>
	<u>5,40,000</u>

(2) Use of Koyna waters for irrigation in area proposed to be irrigated by flow under the upper Krishna project in the Mysore State

For the proposed irrigation of the area under the Almatti and Narayanpur Canals proposed under the upper Krishna Project by the Mysore State, the storage needed for irrigation can either be provided at Helwak on koyna with diversion works at Almatti and Narayanpur or alternatively the storages can also be provided for storing the waters from the Koyna catchment upto Helwak at Almatti and Narayanpur. Two alternative studies are, therefore, made viz. :-

(A) Storage on Koyna at Helwak with diversion works at Almatti and Narayanpur on Krishna

and

(B) Storage and diversion works on Krishna at Almatti and Narayanpur only.

Alternative 'A'

In this alternative, the main storage is provided on Koyna at Helwak. The waters from catchment area of Koyna upto Helwak are then proposed to be released from the Helwak dam and are proposed to be picked up in the Mysore State by two alternative methods described below.

Alternative I

In the first alternative it is proposed to pick up the waters released from Helwak reservoir at the diversion dam at Almatti from which they are proposed to be distributed for irrigation through the Almatti high level canal for irrigation of that canal and by a feeder channel 60 miles long connecting the Almatti left bank canal to the head of Narayanpur left bank low level canal for irrigation in the command of Narayanpur left bank low level canal.

Alternative II

In the second alternative, in addition to the Almatti diversion dam a separate diversion dam at Narayanpur is proposed in lieu of the feeder channels.

Rough alternative studies of cost of providing a diversion dam at Narayanpur versus a feeder channel from Almatti reservoir to Narayanpur left bank low level canal shows that it would be cheaper to construct a diversion dam at Narayanpur as compared to construction of a feeder channel. Apart from this latter proposal of providing a diversion dam at Narayanpur being cheaper, it also reduces transit losses to the extent of a little over 1 T.M.C.

For the purpose of this study, therefore, the following

works are considered :-

- (i) Main reservoir on Koyna at Helwak.
- (ii) Diversion dams at Almatti and Narayanpur.
- (iii) One left bank canal each from Almatti and Narayanpur diversion dams.

Alternative (A)

Storage at Koyna and diversion work at Almatti.

Estimate of costs

Under alternative (A), the following transit and evaporation losses are estimated. The details of transit loss estimation are given in Appendix I Part III.

(1) The reservoir losses at Koyna lake	4.4 T.M.C.
(2) Reservoir losses at the Almatti Diversion weir	9.9 T.M.C.
(3) Reservoir losses at the Narayanpur diversion weir	1.4 T.M.C.
(4) Transit losses between Koyna storage at Helwak and Almatti/Narayanpur diversion works.	19.1 T.M.C.
Total	34.8 T.M.C.

The total 75% dependable water potential available at the Helwak site on Koyna is estimated at 123.3 T.M.C. Deducting the reservoir and the losses of 34.8 T.M.C. as detailed above the balance potential available at the canal heads works out to 88.5 T.M.C. With this water potential at Canal head, the following irrigation is possible on the crop pattern proposed by the Mysore Government for the upper Krishna Project Stage I :-

	Acreage irrigated
Sugar cane	27,000
Light perennials	11,000
Two seasonal (Tur and other pulses)	27,200
Paddy	97,000
Kharif, seasonals (Jowar, Bajri, Maize)	1,36,800
Rabi Jowar	2,46,000
	5,45,000

The storage needed at Koyna for irrigation of 5,45,000 acres works out to 77.2 T.M.C. (Gross). With storage at Koyna it will be possible to deliver 107.0 million units (Kilowatt hours) of firm power annually, for use at Sholapur, at Koyna bus bars equivalent to 100 million units valued at Rs. 25 lakhs at 2.5 nPs. per K.W.H. at Sholapur. There is no potential load centre either near Koyna and accordingly provision for transmission line from Koyna to, say, Sholapur will have to be done. Suitable provision for the transmission line has, therefore, been made under "Costs" in Appendix I.

At Almatti the pondage needed will be for fair-weather reservoir losses of 7.7 T.M.C. plus a pondage of 2.0 T.M.C. i.e. total live storage of 9.90 T.M.C.

Similarly, the pondage needed at Narayanpur will be 1.58 T.M.C. (Live).

The Mysore State had given the cost of the project providing a storage of 22.3 T.M.C. (Live) at Almatti and 2.98 T.M.C. at Narayanpur with canals having a carrying capacity of $1400+2555=3955$ Cusecs as Rs. 4750 lakhs. Deducting Rs. 40 lakhs for reduction

of the dam height at Almatti by 8 feet required to reduce the storage capacity to 9.9 T.M.C. and adding cost of Rs. 994 lakhs for lining the canal and raising banks to carry a discharge of 5520 cusecs, the total diversion dams and canals works out to Rs. 5704 lakhs. The statement of costs is given in Appendix I Part II.

Alternative B.

Storage and diversion works at Almatti and Narayanpur only

The reservoir losses and transit losses from Koyna at Helwak to Almatti/Narayanpur in this case work out to 24.0 T.M.C. as under :

	T.M.C.
(1) Reservoir losses at Almatti for a storage of 31.2 T.M.C. (Live) =	10.0
(2) Reservoir losses at Narayanpur for a storage of 42.8 T.M.C. (Live).	7.2 T.M.C.
(3) Transit losses from Koyna at Helwak to Almatti/Narayanpur sites	6.8 T.M.C.
Total	24.0 T.M.C.

Of the 75% dependable flow of 123.3 T.M.C. of Koyna at Helwak only 99.3 T.M.C. will be available at canal heads after deducting losses detailed above capable of irrigating 6.08 lakh acres as detailed below.

	Acreage irrigated
Sugar cane	30,500
Light perennials	12,000
Two seasonals (Tur and Pulses)	30,500
Paddy	1,08,000
Kharif Seasonals. Jowar, Bajri, Maize	1,53,000
Rabi Jowar	2,74,000
Total	6,08,000

For this irrigation a storage of 31.2 T.M.C. (live) (40.4 T.M.C. gross) will be needed at Almatti and 42.8 T.M.C. (live) (46.0 T.M.C. gross) will be needed at Narayanpur with canal capacities as detailed below :-

Almatti left Bank Canal	2140 cusecs.
Narayanpur left bank canal	4040 cusecs.

The cost of works for various storages and canals is given in Appendix I Part II.

Sri Sailam Hydro-Electric Project

In this project, the Andhra State has proposed construction of a dam across the river Krishna at Sri Sailam for generation of hydro-electric power. The annual water utilisation for generation of power proposed by the State authorities is 276.1 T.M.C. and the power plant proposed to be installed is for 3,30,000 Kws. With the construction of this dam and power plant as proposed, the State would be able to generate 1367 M.Kw. hours of firm power annually. Sri Sailam is located near Singareni collieries. Accordingly, the cost of thermal generation power near the load centres to which the Sri Sailam power is proposed to be transmitted will be cheaper than the corresponding cost of generation of thermal power at Bombay. The estimated cost of thermal generation of power in the area to be served by the Sri Sailam Project is of the order of 2.7 nPs. per Kw. hour. The State Government has estimated the cost of the project at Rs. 3037 lakhs for generation.

The 75% dependable flow of Koyna at Helwak amounting to 123.3 T.M.C. will get reduced to 111.2 T.M.C. by the time the waters reach the Sri Sailam reservoir on account of transit

losses in the river from Helwak to Sri Sailam. The Koyna waters undergo transit losses of 6.8 T.M.C. upto Narayanpur in the Mysore State, as stated in the relevant part dealing with upper Krishna Project. The distance of Narayanpur from Helwak on Koyna is 254 miles. The distance between Narayanpur and Sri Sailam is 236 miles. The river section between Narayanpur and Sri Sailam being much broader than the river section between Helwak and Narayanpur, the estimated transit losses between Narayanpur and Sri Sailam would naturally be expected to be much higher than the transit losses between Helwak and Narayanpur. For purposes of this calculation, however, a flat rate of 0.02 per cent per mile is assumed as the transit losses. On these basis the transit losses between Helwak and Sri Sailam work out to 12.1 T.M.C.

The annual reservoir losses at Sri Sailam are estimated at 33.0 T.M.C. for annual utilisation of 276.13 T.M.C. On the pro-rata basis, therefore, the reservoir losses for the annual utilisation of 111.2 T.M.C. would be 11.30 T.M.C. The net supply available at the canal heads from Sri Sailam will, therefore, be $111.2 - 11.30 = 99.90$ T.M.C. It is this quantum which will be effective in generating power. The total number of units generated annually by utilisation of this quantum of water on pro-rata basis would be 560 M.Kw. hours and correspondingly, the cost of work on pro-rata basis will be Rs. 1290 lakhs.

Incidentally, as the power generation as well as the cost of the project for utilisation of Koyna waters is worked out on pro-rata basis of the Sri Sailam project itself, the assumption regarding the transit losses does not affect the benefit-cost studies. The figures of annual generation of power and the pro-

-rata cost of the project are, however, given to keep uniformity in the entire studies.

The Nagarjunsagar Project Stage I

The Andhra State has prepared a detailed estimate for the Nagarjunsagar Project-Stage I. Full details of various data in respect of this project are given in Appendix I enclosed. The annual utilisation proposed on the three canals two taking off from the Nagarjunsagar dam itself, and one near Vijayawada is 277.6 T.M.C. inclusive of reservoir losses of 14.0 T.M.C. at the Nagarjunsagar lake. The estimated cost of the work is Rs. 13953.0 lakhs. The Koyna waters undergo transit losses of 6.8 T.M.C. upto Narayanpur in the Mysore State, as stated in the relevant part dealing with upper Krishna project. The distance of Narayanpur from Helwak on Koyna is 254 miles. The distance between Narayanpur and Nagarjunsagar is 300 miles. The river section between Narayanpur and Nagarjunsagar being much broader than the river section between Helwak and Narayanpur, the estimated transit losses between Narayanpur and Nagarjunsagar would naturally be expected to be much higher than the transit losses between Helwak and Narayanpur. For the purposes of this calculation, however, a flat rate of 0.02 per cent per mile is assumed as the transit loss. On these basis the transit losses between Helwak and Nagarjunsagar work out to 13.5 T.M.C.

The 15% dependable water supply at Helwak is 123.3 T.M.C. Deducting the transit losses of 13.5 T.M.C. the balance available for use at Nagarjunsagar may be taken as $123.3 - 13.5 = 109.8$ T.M.C.

The annual reservoir losses at Nagarjunsagar reservoir are estimated at 14.0 T.M.C. for annual utilisation of 277.6 T.M.C.

On the pro-rata basis, therefore, the reservoir losses for the annual utilisation of 109.8 T.M.C. would be 553 T.M.C. The net supply available at the canal heads from Nagarjunsagar will, therefore, be $109.8 - 5.5 = 104.3$ T.M.C. capable of irrigating 791.2 thousand acres in various districts under various crops as shown below :-

Crops	Districts					
	Guntur	Kurnool	Nellore	Nalgonda	Khammam	Krishna
	(area in thousand acres)					
Paddy	169.6	2.6	13.0	97.5	54.0	74.5
Dry	226.0	5.3	26.7	52.7	29.1	40.2
Total	395.6	7.9	39.7	150.2	83.1	114.7

The cost of irrigation with the actual utilisation of 104.3 T.M.C. at the canal heads at Nagarjunsagar on pro-rata basis works out to Rs. 5519 lakhs. It may be mentioned here that since the cost of work and irrigation benefits are taken on pro-rata basis, the element of transit losses will not have any effect on the benefit-cost ratio. The figures of possible irrigation and the proportionate cost of work are, however, given so as to keep an uniformity with the studies of similar use of Upper Krishna Project in the Mysore State.

The existing crop pattern in the command of the canals under the Nagarjunsagar Project is given below :-

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Existing pattern of cultivation in the areas proposed to be irrigated

District	Percentage of principal crops : Other perennials	Perennial	Total (T.Acs.)
<u>Nagarjunsagar Right Canal</u>			
1. Guntur		1	
2. Nellore		3	
3. Kurnool		-	
<u>Nagarjunsagar Left Canal</u>			
4. Nalgonda		-	
5. Khammam		4	
6. Krishna		-	

District	Kharif							
	Paddy	Cholam	Sajja	Groundnut	Ragi	Korra	Samal	Castor
Right canal								
1. Guntur	2	28	9	9	-	-	-	-
2. Nellore	10	10	9	-	-	-	-	-
3. Kurnool	6	-	7	-	6	27	8	8
Left Canal								
4. Nalgonda	6	7	13	15	-	-	-	8
5. Khammam	9	11	-	11	-	-	-	-
6. Krishna	7	52	2	16	-	-	-	-

District	Percentage of crops				Percentage of principal crops			
	Green gram	Varigu	Others	Total	Paddy	Cotton	Others	Tobacco
Nagarjunsagar Right Canal								
1. Guntur	-	-	9	-	1	18	11	-
2. Nellore	-	8	21	3	3	-	-	-
3. Kurnool	-	-	6	1	7	-	-	-
Nagarjunsagar Left Canal								
4. Nalgonda	8	-	5	6	1	-	-	-
5. Khammam	19	-	6	-	-	-	-	-
6. Krishna	15	-	2	-	-	-	-	-

District	Rabi				Total (T. acres)	Grand total (thousand acres)
	Percentage of principal crops					
	Cholam	Varigu	Gram	Other Rabi		
Nagarjunsagar Right Canal						
1. Guntur	-	-	-	12		1287
2. Nellore	21	-	-	12		773
3. Kurnool	9	7	8	-		30
Nagarjunsagar Left Canal						
4. Nalgonda	16	-	-	15		302
5. Khammam	38	-	-	2		297
6. Krishna	-	-	2	4		276
						2965

Note: 1: Figures furnished above are approximate covering the ayacut area.

2: These figures are obtained from the season and crop reports of Andhra Pradesh.

APPENDIX IStatement of costs of works(1) Koyna Hydel Project(a) Westward diversion of 67.5 T.M.C.

	Cost in crores of Rs.
1) Storage dam on Koyna storage 58.0 T.M.C. gross	14.30
2) Electrical installations etc. at the main power house at Mankar Wadi (Fophali)	23.06
3) Tail race power station	15.00
4) Cost of electrical installation at the foot of the dam for generating power by flow of tail race into Koyna river	2.175
5) Transmission line from Koyna to Bombay including sub-stations	11.33
Total	<u>65.865</u>

Power generated annually 2150
million k.w.hrs. at bus bars

(b) Westward diversion of 118.0 T.M.C.

1) Storage dam on Koyna at Helwak Storage 98.0 T.M.C. gross	20.00
2) Electrical installations at main power house	23.06
3) Tail race power station	15.00
4) Transmission line Koyna-Bombay including sub-station	11.33
Total	<u>69.39</u>

Annual generation of power

Main power house	3750 million K.W.Hours
Tail race	780 million K.W.Hours
Total	<u>4530 million K.W.Hours</u>

at bus bars.

(2) <u>Koyna Irrigation Project</u>	Cost in crores of Rs.
1) Cost of storage at Helwak on pro rata basis for irrigation part	420.0
2) Cost of Electric Installation at the foot of the dam 27,500 K.Ws. installed	120.0
3) Transmission line from Koyna to Sholapur - 145 miles long	206.0
4) Cost of civil works for irrigation such as pick-up weir at Warunji and canals etc.	1270.0
5) Cost of pumps and pumping installation	30.0
6) Recurring cost of pumping water 37.5 m.k.w.hrs. annually at appropriate rate	---

Benefits :

The following details are given in respect of existing crops and crops proposed under irrigation in the commanded area under this project.

1) Culturable commanded area	
Name of district	Area in thousand acres
Satara	29.9
Sangli	160.6
Kolhapur	12.6
	<hr/>
Total	203.1
	<hr/>

This excludes area under wells.

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2) Existing pattern of irrigation (for the whole area)

Season	Crop	Percentage of principal crops		Total in T. acres	
		Koyna right bank canal	Krishna left bank canal	Koyna right bank canal	Krishna left bank canal
Pere- nnial	Sugarcane	2.5	2.5		
	Others	0.5	0.1	3.5	2.3
Kharif	Jowar	20.2	18.6		
	Paddy	2.0	2.7		
	Groundnut	22.0	18.1		
	Others	1.6	1.5		
	Pulses	6.4	8.0	62.1	43.6
Rabi	Jowar	29.9	27.8		
	Wheat	2.7	3.6		
	Pulses	6.4	8.0		
	Others	1.1	4.0	47.8	38.9
Hot weather	Drugs	3.1	2.6		
	Others	1.6	2.5	5.6	4.6
	Total	100.0	100.0	119.0	89.4

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3) Proposed Crop Pattern

Season	Crop	Percentage of principal crops		Total in T. Acres	
		Koyna right bank canal	Krishna left bank canal	Koyna right bank canal	Krishna left bank canal
Pere- nnials	Plantains, sugarcane, etc.	8	8	11.6	8.7
Two season	Onions vegetables chillies	6.8	6.8	10.0	7.5
Kharif	Jowar and Groundnut	28.1	28.1	59.4	44.9
	Paddy	12.9	12.9		
	Long staple cotton	24.0	24.0	34.7	26.3
			Total	115.7	87.4
				203.1	
Hot weather	Groundnut (double cropping)	7.6	7.6	11.3	8.3
Rabi	Gram on paddy (double cropping)	12.6	12.6	18.3	14.0
				145.3	109.7
				255.0	
	Deduct irrigation under existing Krishna canal			-	7.2
				145.3	102.5
	Additional irrigation			247.8	

BIJAPUR LIFT IRRIGATION SCHEME

Statement showing the cost of works required for irrigation by lift in Bijapur district of Mysore State from Koyna Water resource up to Helwak dam site.

	Cost in lakh rupees	
	1948-49 rates	1950-51 rates
(A) Storages :		
(1) Storages on Koyna at Helwak. Capacity (gross) in T.M.C. 75.0	-	1740.00
(2) Cost of electric installation at the foot of Koyna dam. Installed capacity 4 units 18500 KWs.	-	280.00
(3) Cost of transmission line from Koyna dam to Hirepadsalgi 127 miles long double circuit (0.47 sq.ins.) (0.2 sq. inches of equivalent copper)	-	168.00
(4) Cost of transmission line from Kali nadi to Hirepadsalgi 128 miles long double circuit (0.35 sq. inches of equivalent copper).	-	370.00
(5) Additional sub-station and power lines from one lift station to others- long d'ble circuit -		37.00
(6) Cost of pick up weirs at i) Ainapur) ii) Halial) iii) Hirepadsalgi) iv) Chimalgi (Almatti))	87.66	109.83
(7) Cost of Civil Works for pumping installations etc.	235.50	294.37
(8) Cost of pumps	658.00	822.50
(9) Cost of rising mains, valves, etc.	1109.00	1386.25
(10) Cost of canals and distribution system	3010.00	3762.50
	-----	-----
Total		8950.45
		say 8951 lakhs.

Recurring Cost

In this proposal the entire quantum of power viz. 300 million K.W.Hours of power generated at the foot of the Koyna dam at Helwak is proposed to be transmitted to the pumping sites and utilised for pumping. In addition, 577 million K.W. Hours of power delivered at the pumping sites is required for pumping water for complete irrigation as proposed.

The transmission losses at 7 per cent may be added to this requirement of 885 m.k.w.hrs of the power bought at bus bars at the generating station.

UPPER KRISHNA PROJECT

(Storage on Koyna and diversion works at Almatti and Narayanpur.)

	Cost in lakh Rs.
1) Storage on Koyna at Helwak Capacity 77.2 T.M.C. (Gross)	1780
2) Cost of electric installation at :	
(a) the foot of dam at Koyna installed capacity 4 x 8000 KWs.	140
(b) Transmission line from Koyna dam to Sholapur - 145 miles long	206
3) Cost of diversion works at Almatti and Narayanpur with cost of canals and distribution system	5704
Total	7830

UPPER KRISHNA PROJECT

(No storage on Koyna at Helwak and storages and diversion works at Almatti and Narayanpur only.)

	Cost in lakh Rs.
1) Cost of storages at Almatti and Narayanpur with cost of canals for irrigation of 608 thousand acres	7380
No power generation	-
Total	7380

THE SHRI SHAILAM PROJECT

	Cost in lakh Rs.
Cost of whole project:	
(1) Cost of Civil works	2345.0
(2) Electrical Installation including transmission lines etc.	692.0

Total	3037.0

THE NAGARJUN SAGAR PROJECT STAGE 1

	Cost in lakh Rs.
(1) Cost of all Civil works, i.e. dam, canals, etc.,	13953.0

APPENDIX - I (Part II)A Note on transit losses in river Krishna

Transit losses in the river between Koyna at Helwak and Krishna at almatti/Narayanpur and between Koyna at Helwak in Maharashtra State and the lift irrigation sites in the Bijapur District of Mysore State.

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It is a well-known fact that certain amount of transit losses take place, as water moves from one place to the other. In case of unlined irrigation canals, the practice followed in Northern India as well as in Andhra Pradesh is to estimate the canal losses at 8 cusecs per million square feet of contact surface. Transit losses, in case of lined channels are estimated at 1/3rd of this rate, i.e. 8/3 cusecs per million

square feet of contact surface.

In an unlined irrigation channel in addition to other losses, a substantial element of loss is due to seepage as the channel is generally situated at a higher level from which water seeps into the soil and goes underground. In case of lined canals, however, the seepage losses are almost negligible.

In the case of a river being a drainage channel into which seepages from the adjoining areas flow in constituting what is known as Post Monsoon flow, the seepage losses may be considered as negligible, since the river generally flows at the lowest level. Ordinarily the post monsoon flow depends on the amount of water retained in the sub soil in the catchment area of the river which finds its way into the river on account of the effective head available between the free water surface in the river and the water table in the strata surrounding it. When the water level in the river happens to be higher, the amount of the post monsoon flow getting into the river is correspondingly low and when the water level in the main river goes down, more post-monsoon sub soil flow finds its way into the river since a correspondingly higher head becomes available for the sub soil flow into the river.

During the monsoon period the water level in the river is generally high and there are hardly any seepage losses in the river. Accordingly it would not be incorrect to assume that the river behaves in this period like a lined canal in which the seepage losses are negligible. In the fair weather

period, however, with higher flows in the river due to release from storages, i.e. with higher water level in the river, post monsoon inflow would get reduced due to availability of less head. This means that although there are no actual seepage losses in the river the normal discharges in the river in fair weather period, would get reduced to the extent to which the head available for the inflow of sub soil water into the river is reduced due to higher water levels in the river than the normal levels. In effect, this amounts to a loss of water representing the water ordinarily available in the river but which does not become available due to higher water level in the stream; although this does not constitute a seepage loss. If, therefore, the river is treated as lined channel, during the post-Monsoon period, for the purposes of estimating river losses, such an estimate of loss would be on the lower side than the corresponding estimate of loss in the lined channel, to the extent, to which the inflow of sub soil water into river is prevented from flowing into the river due to higher water level in the river due to larger discharges during the fair weather period under natural conditions.

In the case of estimation of transit losses in the river from Koyna dam site to lift irrigation sites on Krishna and to Almatti/Narayanpur diversion works it is assumed that the losses are of the nature of 2.5 cusecs (instead of $8/3 = 2.67$ cusecs) per million square feet of contact surface. The cross section of river Krishna at Kusnal together with the characteristics of the cross sections at different levels are available and are printed in the Bombay P.W.D. Technical

Paper No.30. The sections of the river below Kusnal are very large and those above Kusnal are correspondingly small. Kusnal sections may, therefore, be taken as the average cross section for the flow of the river between Koyna and Narayanpur.

The estimated average discharges passing Kusnal during Kharif, Rabi and hot weather were first worked out by using Inglis' formulae. From these discharges the contribution from Koynareservoir catchment area up to Helwak and the proposed utilisation of water resource of Krishna in Maharashtra for irrigation was deducted to arrive at the average normal flow at Kusnal after operation of all irrigation works upstream of Kusnal. Corresponding to these average discharges the transit losses between Koyna dam site at Helwak and lift irrigation sites and Almatti and Narayanpur were worked out for each season. These losses represented normal losses of river in these conditions. The normal losses worked out in the manner described above are given below :-

1) Kharif season	22.9 T.M.C.
2) Rabi season	14.3 T.M.C.
3) Hot weather season	Nil

Total 37.2 T.M.C.

After the normal river losses were estimated in the manner indicated above the transit losses on account of increased discharge due to controlled releases from Koyna dam at Helwak for irrigation from Narayanpur and Almatti canals were added to the normal discharges of river Krishna at Kusnal referred to above. From these discharges including the releases from Koyna, transit losses were again worked

cut for the three seasons indicated above.

The extra transit losses on account of release of Koyna waters from Koyna for utilisation on each of the alternative uses were obtained by working out the difference between these normal transit losses and the new transit losses. This gave the net extra transit losses due to utilisation of water for irrigation in the Krishna valley.

The following table gives the transit losses for various alternative uses for irrigation in Krishna valley:-

Transit losses in T.M.C.				
	Season	For flows in Krishna at Kusnal including controlled releases from Koyna up to Helwak	For normal flow of Krishna at Kusnal	Extra transit loss due to Koyna releases
I Storage on Koyna at Helwak with lift irrigation from pick up weirs at Aina-pur, Halial, Hirapadsalgi & Chimalgi(Almatti)	Kharif	26.0	22.9	3.1
	Rabi	15.8	14.3	1.5
	Hot weather	14.5	Nil	14.5
	Total	56.3	37.2	19.1
II(A) Storage on Koyna at Helwak with diversion works at Almatti and Narayanpur	Kharif	26.0	22.9	3.1
	Rabi	15.8	14.3	1.5
	Hot weather	14.5	Nil	14.5
	Total	56.3	37.2	19.1

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	Season	For flows in Krishna at Kusnal with flows of Koyna up to Helwak without storage at Helwak	For normal flow of Krishna at Kusnal	Extra transit loss due to Koyna waters only
II(B) Storages and diversion works on Krishna at Almatti and Narayanpur only	Kharif	29.5	22.9	6.6
	Rabi	14.5	14.3	0.2
	Hot weather	Nil	Nil	Nil
	Total	44.0	37.2	6.8
