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LABOUR-BASED TECHNOLOGY FOR LARGE IRRIGATION WORKS: PROBLEMS AND PROSPECTS

by

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Note: Working papers are preliminary material circulated to stimulate discussion and critical comments.

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PREFACE

This is the fourth in a series of working papers on irrigation technology. The paper attempts to summarise the state-of-the-art of labour-based technology for the construction of large irrigation works.

In the construction of these works the use of some equipment is necessary for technical and economic reasons. However, based on the evidence, mainly from India and China, the author, Dr. Biswas, Vice-President, International Water Resources Association, concludes that there is enormous employment potential in the construction of large irrigation projects. To exploit this potential, it is necessary to identify those items of work which are conducive to the use of labour-based methods, to use project designs appropriate to the application of labour-based methods and to develop managerial capacity to recruit and organise large groups of labourers.

While the emphasis in this paper is mainly on irrigation projects, it should be noted that a significant part of the discussions, especially that pertaining to the construction of dams and ancillary works, could also be relevant for dams built for hydroelectric generation. This point assumes some significance today in view of the continuing escalation of fossil fuel prices, in response to which many developing countries are now building or planning to build, single-purpose hydrodams in areas where irrigation is of minor importance.

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TABLE OF CONTENTS

I. INTRODUCTION

With increasing world population, it is imperative that the basic needs of the increasingly growing number of people should be satisfied. One important basic need is productive employment, which is one of the most acute contemporary social problems of virtually all developing countries. It has been estimated that some 75 million people are currently unemployed (UN, 1979; Thiesenhusen, 1974), and according to both ILO and the World Bank, some 1 billion new jobs have to be created between now and the year 2000. The average annual percentage growth rate of the labour force in developing countries is estimated to grow from 1.8 during 1960-70, to 2.2 in 1970-90, and to 2.1 during 1990 to 2000 (World Bank, 1979). This means that creation of new employment opportunities for people entering the labour force will become more difficult in the future than in the past due to the increasingly rapid growth of the labour force. Reduction in the rate of population growth, while desirable and essential for the long-term solution, will not reduce the magnitude of the problem over the short run, since the entrants to the labour force for the next 20 years have already been born. Furthermore, there has been an increase in absolute number of workers in the agricultural sector of nearly all developing countries, which raises serious questions on the validity of the assumption that industrialisation will reduce total unemployment. Even in countries like the Republic of Korea, the percentage of the labour force in agriculture decreased from 70 per cent to 50 per cent during the period 1950 to 1970 due to the growing demand for industrial labour, but the number of agricultural workers in absolute terms still increased (World Bank, 1979). Consideration of both unemployment and underemployment makes the problem even more serious for most developing countries (Sabot, 1979).

From past experiences in many developing countries, irrigation can be viewed as a means of creating new employment opportunities (Abbas, 1977; Anon., 1978; Ellman and Pingle, 1978; Griffin and Ghose, 1979). The future employment potential from construction, operation and maintenance of irrigation works is enormous, especially in developing countries, where much of the new construction will occur and where unemployment problems are most serious. According to rough estimates made by FAO on the basis of Indian experiences, it appears that for every irrigated hectare, some 4 man-years of employment can be generated during the construction process, and another 25 man-years are required for agricultural activities during the life of the project (Sagardoy, 1976).

According to FAO (1977) estimates, the magnitude of irrigation programme to be executed by 1990 in developing countries can be realised from the following statistics:

- 22 million hectares of new irrigation,
- 45 million hectares of improved irrigation,
- 78 million hectares of drainage,
- 440 thousand million m^3 of additional irrigation water,
- 97 thousand million dollars of investment at 1975 prices.

Employment generation can be increased by a prior decision so that planners and engineers consciously attempt to construct and operate these irrigation schemes by labour-intensive methods (Biswas, 1979; Programme Evaluation Organisation, 1965, ILO, 1978) and employment generation is specifically accepted as an integral part of the over-all socio-economic and technical criteria by which alternative plans are judged and selected (Carruthers and Mountstephens, 1978).

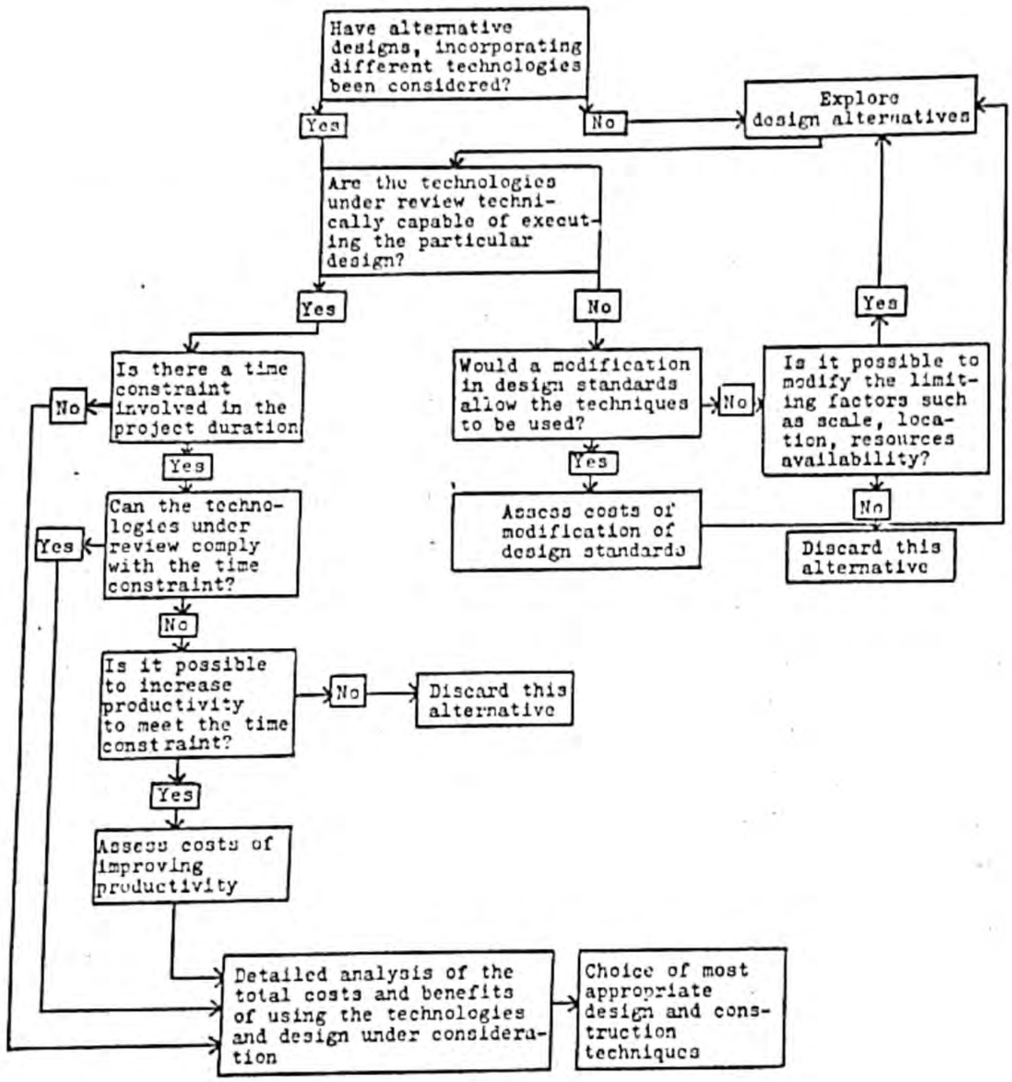
While labour-based construction techniques for irrigation projects have received the attention of planners and engineers for a long time, attempts to use them on a continuing basis can best be described as timid and half-hearted. The few examples of determined attempts by a handful of dedicated men to introduce labour-intensive methods were mostly isolated efforts (Sagardoy and Faragó, 1973). Even in these few cases extensive documentation of the techniques used, their costs and effectiveness, and other relevant information are not readily available, even though they may exist as internal project reports or in files and thus not easily accessible. A cynic might be tempted to say that the virtues of labour-intensive irrigation projects, like chastity, are more often preached about than practised!

The lack of emphasis and realisation of the importance of labour-intensive irrigation works in contributing to employment creation can easily be proven by considering the first-ever United Nations World Water Conference (Biswas, 1978; UN, 1978), held at Mar del Plata, Argentina, in March 1977. Even though some 329 background papers and country papers, covering some 6,000 pages, were presented on all aspects of water resources development, it is revealing to note that only one paper was devoted to the discussion of the employment potential of such developments. The paper was by ILO (1977), and represented less than one-third of 1 per cent of all papers presented. This situation, unfortunately, is a norm rather than an exception. One can even argue that on a percentage basis, labour and employment issues were probably better represented at Mar del Plata than customary at "normal" water resources meetings!

While labour-based construction techniques have not been used extensively to the extent of optimising employment creation, there is no doubt that such practices have been successfully used for the construction of many large irrigation projects in countries like China or India as will be discussed later. It should, however, be realised that both labour and equipments are essential for any project, and the real question is the extent of their use in a specific project. Even for a labour-surplus economy, it is not possible to construct every item of a large-scale irrigation works exclusively by labour only: some equipment is essential for technical and economic efficiency criteria. What is important is the determination of appropriate mix of labour and equipment in keeping with national objectives and requirements.

For large-scale irrigation works, given the will, there exists considerable potential for using labour-based construction techniques in developing countries. It should, however, be realised that the decision to use labour-intensive technology depends on a multitude of factors, inter alia, economics, project type (i.e. certain designs are more appropriate for labour-based construction), construction time, quality requirements, availability of labour and equipment, mangerial capability and socio-political considerations. Hussain (1978) has provided a flow diagram for the evaluation of the most appropriate design and construction techniques. This suggested procedure is shown in figure 1.

Figure 1: Flow diagram for evaluation of most appropriate design and construction techniques



Source: Hussain, 1978.

The rest of the paper is divided into four parts. The first part deals with works conducive to labour-based construction, i.e. earthwork and masonry and concrete work. The second part outlines different potentials of labour-oriented designs which would increase the labour components of the construction of irrigation works. The third part discusses different aspects of project planning and management. The final section points out the major constraints for using large labour forces for the construction of irrigation works.

II. WORKS CONDUCIVE TO LABOUR-BASED CONSTRUCTION

Many components of large-scale irrigation projects can be constructed by labour-based methods, if so desired. Naturally, acceptance of the use of labour-intensive techniques as a primary objective in the construction of a project will have some benefits and will simultaneously pose some constraints which will be discussed later in this report. Hence, from a decision-making viewpoint, it becomes a question of trade-off as to which alternative provides the maximum benefits at the least possible economic and social costs. Such decisions, however, are not always either easy or clear-cut because many qualitative considerations are involved, on which quantitative values are difficult to assign with any degree of accuracy. Thus, the decision-making process invariably has a subjective component which is dependent on the value judgement of the people making the decisions.

Irrigation projects can be broadly divided into five categories of work. These are:

(i) head-works, including the construction of a storage dam or barrage, spillway, outlet mechanism or head regulator, coffer dam, diversion tunnels, and the construction of colonies for workers;

(ii) canal proper, including excavation and bank preparation, construction of canal lining, cross drainage system and other ancillary works like approach roads;

(iii) distribution systems, which are essentially similar to the works described in (ii) but are relatively smaller in size but spread over larger areas;

(iv) works in connection with on-farm development, including land levelling;

(v) land drainage works, including carrier drains for discharging storm run-off from the fields and field drains to the main natural drainage channel.

If the above different categories of works are analysed, it soon becomes evident that there are three items which are common to all, and which can be effectively carried out by labour-based techniques. These are earthwork, concreting and masonry work.

Earthwork: Earth moving and spreading is often the most important and extensive labour-intensive component in many irrigation works. For example, construction of earth dams, coffer dams, land reclamation, flood protection schemes, and measures like land levelling, site preparation, etc., all need an extensive quantity of earthwork. This also means that the potential for using large numbers of workers to carry out the relevant tasks is quite promising. For example, for the Mayurakshi Reservoir Project in West Bengal, India, 70 per cent of the total estimated cost for earthwork was for the labour component only: the figure for masonry was about 30 per cent of the total cost (Aich, 1979). Table 1 and table 2 show the extent of earthwork involved, including the labour components, for the Pench Project in Maharastra (Bhale Rao, Shukla and Kulkarni, 1979) and the Tawa Project in Madhya Pradesh (Hiremath, 1979). Both the projects are in India.

Table 1: Labour component of major items in Tawa Project, India

Items	Total cost (10^5 Rs)	Labour cost (10^5 Rs)	Percentage
Masonry dam			
Foundation excavation			
Overburden	6.44	5.47	85
Rock cut	52.55	34.16	65
Total	58.99	39.63	67.18
Cement concrete	173.46	41.98	24.2
Masonry	392.11	121.45	31.0
Earth dam			
Pitching and boulder toe	33.47	16.73	50.0
Earthwork by machine	342.64	22.27	6.5
Total	376.11	39.00	10.37
Canal systems			
Earthwork	1 177.11	1 000.54	85
Masonry and concrete	2 158.11	604.00	28
Total	3 335.22	1 604.54	48.10

Source: Hiremath, 1979.

Table 2: Labour components and their costs for the Pench Project, India

Type of work	Cost in million rupees		Labour cost as % of total cost	Labour potential (million man-days)	Max. labour strength reached
	Total	Labour component			
Kamthikhairi pick-up					
Weir					
Masonry	70	30	43	2.0	2 000
Earthwork by machine	30	3	10	0.6	100
Pench left bank canal	300	225	75	18.8	7 000
Pench right bank canal	130	97.5	75	8.1	5 000

Source: Bhale Rao, Shukla and Kulkarni, 1979.

Earthmoving normally includes the following basic tasks: excavation (E), loading (L), hauling (H), unloading (U) and spreading (S). The important consideration in terms of economics of labour utilisation is often the hauling distance (Sagardoy, 1976). The decisions to use earthmoving equipments or labour or some combination of the two depend on hauling methods and distance. Comparative costs of excavating, loading, hauling, unloading and spreading by different techniques are shown in table 3 and figure 2 (World Bank, 1975). From this analysis, it appears that for an unskilled labour daily wage rate of $0.50, the least expensive method is wheelbarrow for distances up to 200 m, beyond which mulecart becomes more economic. Labour components for both these methods are quite high, representing approximately 80 per cent and 40 per cent respectively, of total cost. At this wage level, both the labour-intensive headbasket method and capital-intensive flat-bed trucks were not very efficient as shown in table 4.

Table 4 shows optimal techniques for earthwork based on differing wage rates for unskilled labour and varying hauling lengths. The interesting finding was that the most labour-intensive method of earthwork, the traditional headbaskets method, was inefficient under any of the assumptions of wage rates made or hauling lengths considered. Machine-intensive methods were found to be more efficient for daily wage rates of $1.00 or more.

Similar studies by ILO in the Philippines indicate that at the prevailing market prices during 1973-74, the most economical combinations for excavating and hauling for road construction are as follows (Lal, 1978):

Hauling distance (m)	Cheapest methods
0-25	Bulldozer
25-250	Caraboo-drawn cart, hand-loaded
250-5 000	Tractors/trailers, hand-loaded
5 000+	Dump truck/payloader

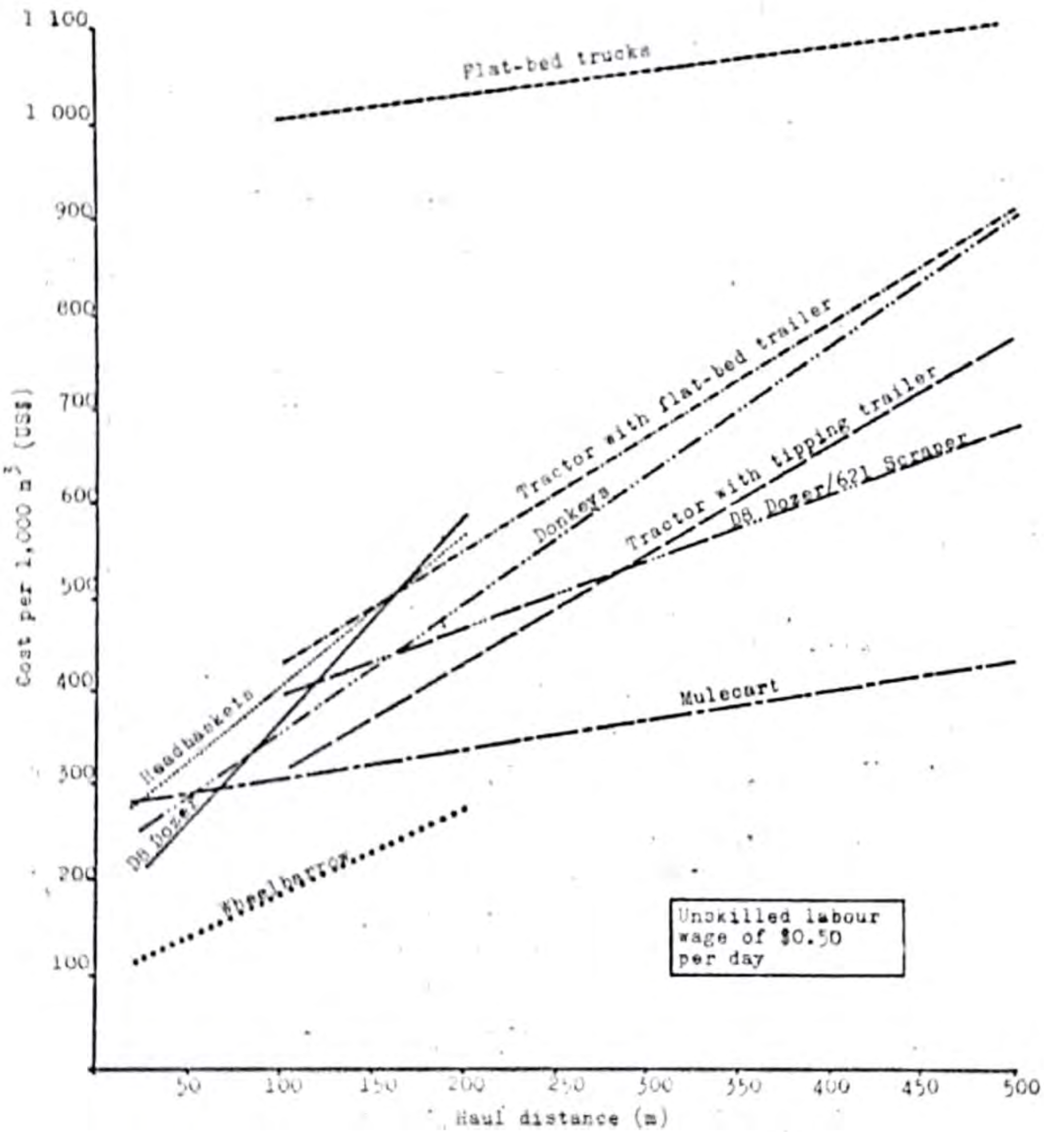
A word of caution is appropriate here with respect to the findings of table 4. The analysis was based on data available on the early seventies. The costs of different earthmoving equipments have increased significantly since that time, but the wage rates in developing countries have not gone up commensurately. Furthermore, the operation and maintenance costs of machines have increased, in part due to significant increase in oil prices since October 1973. Finally, an implicit assumption of the analysis was that the equipments could be used on a continuing basis, which in many instances prove to be incorrect. This is especially true if they belong to government departments, where frequently equipments are not used for a prolonged period after construction of the project, for which they were initially purchased. For example, in the Philippines, the economic life of a piece of equipment could range from 20,000 or more, to as little as 2,000 machine-hours, compared to 10,000 hours in developed countries (Lal, 1978). Many of the equipments supplied under aid programmes cannot be properly maintained due to lack of spare parts as well as trained personnel to repair them. Lack of maintenance and adverse climatic conditions contribute to the reduction of economic life of the machinery. However, the general trend of table 4, that at higher wage rates machines tend to be more economically efficient, remains generally valid.

Table 3: Costs per 1,000m^3 of bulk excavation (E), loading (L), hauling (H), unloading (U) and spreading (S) of cohesive soils. Unskilled labour wage $0.50 per day

Method	Haul lengths (m)				
	25	50	100	200	500
E & L Manual H Headbaskets U & S Manual	295 100	334 100	413 100	556 100	- -
E & L Manual H W-barrow U & S Manual	144 81	161 80	196 80	266 79	- -
E & L Manual H Donkeys U & S Manual	255 40	287 37	351 32	478 27	859 20
E & L Manual H Animal Carts U & S Manual	282 41	297 40	328 38	329 37	423 33
E & L Manual H Tractor & Flat-bed Trailers U & S Manual	- -	- -	429 32	534 27	898 20
E & L Manual H Tractor & Tipping Trailers U & S Manual	- -	- -	319 36	431 27	768 17
E & L Manual H Flat-bed Trucks U & S Manual	- -	- -	1 008 20	1 032 20	1 090 20
ELHUS Dozer	232 1	319 1	593 1	- -	- -
ELHUS Dozer-Trailer	- -	- -	385 1	473 1	661 1

Source: World Bank, 1975.

Figure 2: Costs of earthworks by different methods



Source: World Bank, 1975.

Table 4: Optimum solution for earthwork at different wage rates and hauling distances

Daily wage rate	Hauling length in metres				
	25	50	100	200	500
$1.25	Dozer	Dozer	Dozer/Scraper	Dozer/Scraper	Mulecart
$1.00	Dozer	W-barrow	W-barrow	Mulecart	Mulecart
$0.75	W-barrow	W-barrow	W-barrow	W-barrow	Mulecart
$0.50	W-barrow	W-barrow	W-barrow	W-barrow	Mulecart
$0.25	W-barrow	W-barrow	W-barrow	W-barrow	Mulecart

Source: World Bank, 1975.

It is useful at this point to discuss some of the labour-intensive practices in the People's Republic of China in earthmoving techniques. Information available at present is somewhat sketchy, but the following summary will present a useful picture of current developments in that field.

No comprehensive official data are available on the total extent of irrigation and attendant agricultural construction in China, but some estimates are available at present (Nickum, 1979, 1978, 1975) based on fragmentary evidence. Hence, the statistics quoted here should be considered as indicative rather than definitive.

In order to use surplus labour effectively during the winter months, extensive farmland and water conservancy capital construction projects are undertaken, mostly at the local or subprovincial level. This process is called "capital formation labour accumulation". For example, as shown in table 5, during the 1977-78 winter construction period alone, over 100 million people were employed in over 1 million water resources construction projects. During this year, the following tasks were carried out (Nickum, 1979):

- moving 19,000 million m^3 of earth and stone;
- constructing and upgrading 2.7 million ha of irrigation facilities;
- taking correcting measures to free 2 million ha of land from salinity and waterlogging;
- levelling of 6.4 million ha; and
- building terraces on 600,000 ha.

The major difficulties in determining the reliability of such data are two-fold. First, not all statistics on irrigation projects are forwarded to a central point, Peking. Second, it is not exactly unusual to receive fictitious data because of strong campaign demands. Viewed in any fashion, the fact, however, remains that the extent of labour use in China on irrigation works is of immense magnitude.

At this stage it may be useful to provide some data from the construction of specific irrigation projects in China. For the Kuochuang Dam on the Sungi River, a labour input of 1.05 million man-days was required. The dam was an earth-fill

Table 5: Magnitude of winter labour use and earthwork in China, 1964-78

Year	Labour force (millions)	Earthwork (10^3 million)
1964-65	30-40	3.5
1965-66	40-60	3.5-4.5
1966-67	40-60	3.5-4.5
1967-68	30-45	2.0-2.5
1968-69	50-60	2.5-3.0
1969-70	60-80	3.5-4.5
1970-71	90	5.0
1971-72	80-90	4.0-4.5
1972-73	85-95	4.5-5.5
1973-74	110	6.0
1974-75	110-130	15.0
1975-76	130-150	25.0
1976-77	120-140	15.0
1977-78	100	19.0

Source: Compiled from Nickum, 1979, 1978, 1975.

one, with a natural stone core. Approximately 1.7 million m^3 of earth were moved by hand (Henle, 1974). For the Haiho River Control Project in northern China, mass labour was mobilised, comprising 300,000 to 400,000 workers each winter, at the main construction sites. Another 1 or 2 million workers were employed for the ancillary construction projects, making an annual total of labour input exceeding 45 million man-days. Total volume of earthwork was estimated at 1,900 million m^3 (Henle, 1974). Similarly, two major dams were constructed from 1958 to 1960 as a collective labour project on Chaoho and Paiho Rivers, tributaries of the Haiho River, as a part of the "great leap forward". Labour brigades of some 200,000 workers, comprising of mainly farmers, worked on the scheme during slack seasons. Tools used were primarily shovels, picks, shoulder baskets, carrying poles and wheelbarrows. On an average, there were never less than 100,000 workers at the site. Over 70 million man-days were utilised for their construction. Some 38 million m^3 of earth had to be moved for the construction of one of the dams, Peipaiyen, which was 4,550 m long and 160 m high. The project provided irrigation water for 280,000 ha, and 400,000 ha was protected against annual flooding. Some 80,000 ha of waste land was reclaimed for farming, and another 135,000 ha of waste land and silted river beds were reforested (Henle, 1974).

Similarly for the first phase of Hai River development programme, wherein 34 channels having a total length of 3,700 km had to be dug, 600 million man-days were utilised for 1,700 million m^3 of earthwork. Between 300,000 to 500,000 workers were employed during each construction season (Nickum, 1978). There is no doubt that a significant percentage of the technology currently being used in China can also be utilised in several other developing countries, perhaps with some modifications to account for differing social, economic and political conditions.

Thus, comprehensive study of current labour-intensive irrigation construction processes in China will undoubtedly be of considerable value, and should be undertaken as soon as possible.

Limited data available on productivity of the Chinese workers for irrigation construction projects are shown in tables 6 to 9 (Nickum, 1975).

Table 6: Norms of earthwork in China per 100 m^3 of natural earthwork

Type of materials	Unit	Type of soil			
		Sandy, sandy + loam, cultivated (1)	Loam, cultivable loess with grass roots (2)	Dry loess, clay, heavy clay, clay with small amounts of gravel (3)	Hard clay, granitic clay, pebble clay (4)
Hand digging	Man-day	4.68	7.92	15.84	26.29
Excavation by					
(i) blasting labour	Man-day	-	-	0.32	0.65
(ii) ordinary labour	Man-day	-	-	0.65	1.29
Total	Man-day	-	-	0.97	1.94
Potassium nitrate	Kg	-	-	8.00	10.00
Fuse	Meters	-	-	50.00	50.00
Tubes	Sticks	-	-	50.00	15.00

Source: Shuitu Baochi, 1973, p. 207.

Table 7: Norms of earthwork loading/unloading and hauling per 100 m^3 of natural earthwork in China

Labour or machinery	Unit	Loading/unloading				Hauling 10 m on level ground			
		Type of soil				Type of soil			
		(1)[1]	(2)[1]	(3)[1]	(4)[1]	(1)[1]	(2)[1]	(3)[1]	(4)[1]
Shoulder pole	Man-day	19.80	20.56	23.36	26.18	2.75	2.75	3.03	3.30
Single wood wheel cart	Shift	18.40	19.47	22.44	25.41	2.26	2.26	2.49	2.71
Single rubber wheel cart	Shift	18.11	19.14	22.11	25.08	1.13	1.13	1.24	1.36
Frame cart	Shift	10.90	11.20	12.60	14.04	0.63	0.63	0.69	0.75

[1] Soil types correspond to same as in table 6.

Source: Shuitu Baochi, 1973, p. 207.

Table 8: Comparison of labour productivity between tamped dams and pour-fill dams in China

Construction method	Earthwork on dam (m^3)	Dam height (m)	Man-days	Earthwork per man-day	Date completed
Hand-tamped	3 000	18	1 680	1.8	1969
Pour-fill	14 500	21	1 240	11.7	1970
Pour-fill	100 000	30	12 000	8.3	1971
Pour-fill	9 000	15	1 755	5.2	1972

Source: Daba Yudi, 1973, p. 75.

Table 9: Comparison of funds per m^3 of earthwork in China

Construction	Earthwork (m^3)	Oil consumed (kg)		Funds expended (¥)	Earthwork per kg diesel oil	Funds per m^3 earthwork
		Diesel	Machine oil			
Hand-tamped	3 350	-	-	170	-	0.050
Pour-fill	8 060	191	26	124.83	42.0	0.015
Pour-fill	14 500	170	20	112.40	85.0	0.008

Source: Daba Yudi, 1973, p. 76.

Masonry and concrete work: Both masonry and concrete work provide a good basis for using labour-based construction techniques. For large-scale irrigation projects, dams to be constructed are generally high and accordingly the height of lift is often more than 60 m, having daily requirements of mortar and concrete over 300 m^3. Such requirements appear to be high at first sight when viewed in terms of labour-based construction only, but much higher figures have been achieved by appropriate planning and design. A good example is the Nagarjunasagar Project in India.

The Nagarjunasagar Dam is located on the River Krishna in Andhra Pradesh and was constructed over the nine-year period, from 1955 to 1964. It appears to have benefited from a 1955 policy statement of the Government of India that more emphasis should be placed on increasing employment opportunities in construction projects instead of heavy reliance on mechanisation (Bliss and Reedy, 1974). Accordingly, a decision was taken to make Nagarjunasagar a masonry dam, the highest in the world, having a height of 124.7 m above the deepest foundation level. The length of the dam is 3,424 m, and the volume of masonry used in the dam was 4.87 million m^3 (Purushottam, 1979).

The Nagarjunasagar is an excellent example of how a major irrigation project can be constructed primarily by labour-based construction techniques. It used minimum mechanisation, and machines were used only where labour could not carry out the tasks effectively, such as tunnelling, carrying earth over very long distances, or lifting large blocks of stones over great heights. The cost of the machinery used was equivalent to about 4 per cent of the total project cost (Bliss and Reedy, 1974). It was estimated that economy in capital cost resulted in the saving of some Rs.40 million. Furthermore, Indian engineers constructed the project without any foreign advice or assistance.

For the Nagarjunasagar Dam, the concrete mixing was done by batching plants located about 1 km from the site. The mixture was carried by tippers and lorries, the latter being unloaded by manual labour at the toe of the dam. Scaffolding was erected with bamboo and causarina poles up to a height of about 45 m, with easy flights and landings for labourers to carry mortar, concrete or rubble by head-baskets. The vertical lift of 45 m was a constraint, mainly due to the initial setting time of concrete of 30 minutes which could not be exceeded by the conveying process. Where the lift exceeded this range, belt conveyers and cranes were used to convey material to the construction site. The techniques used worked well, so much so that the record progress for a single day was 7,140 m^3 of masonry, a remarkable achievement under any circumstances (Purushottam, 1978).

Another masonry dam is the Tungabhadra in India, which required 32 million cu ft of material for construction. It was constructed in slightly over five years. An average of 40,000 cu ft was laid per day, the peak rate being approximately 50,000 cu ft. Some 400 masons were involved, each extending a 1 ft layer of new stone covering an area of 8 to 10 sq ft every day. Lighter stones, weighing up to 80 lbs were carried on the head by the labourers and were unloaded at specific locations by masons' helpers. Larger pieces of granite weighing up to 400 lbs, slung from two stout bamboo poles by a light chain, were carried by four-men teams. Since the strength of the masonry depends on the strength of the mortar, design, mixing and laying of mortar were carefully supervised. Masonry was laid manually but small power-driven mixers were used extensively for preparing mortar and concrete. The average cost of each 100 cu ft of masonry laid at the Tungabhadra was Rs.128 or Rs.132, the cheaper rate being for the lime-soorke mortar (Khan, 1966).

For the Kan Ju Tan Hydroelectric Project in China, some 5,000 workers were engaged for the earthwork and to build a 654,000 cu yd embankment. Concrete mixing for the project was carried out manually. Sledgehammers were used to break boulders into aggregates. Stones were transported mostly by basket pole method, and some by wheelbarrows, from a quarry nearly 1 1/2 miles from the site (Bliss and Reedy, 1974).

In Egypt, for the construction of a new head regulator for the Ismailia Canal, a total of 39,000 m^3 of concrete was used during a period of two years. A stationary concrete mixing plant was set up about 100 m from the worksite, with three mixers of 0.5 m^3 capacity each. A bulldozer was used for handling the material in the plant yard and three hand-operated scrapers for loading the material into the mixing plant. The concrete was transported from the mixing plant to the placing areas in two stages. In the first stage, the concrete was transported in the tippers and then it was unloaded in the wooden spouts. These spouts were erected at suitable slopes to take the concrete down to the lower levels in areas where it was required. The entire concrete was placed in the forms, for foundation and superstructure works, by manual labour (Amer, 1980).

Thus, considerable scope exists for application of labour-based techniques for construction of large-scale irrigation works using concrete and masonry, especially the latter.

III. LABOUR-ORIENTED DESIGNS

Generally for large-scale irrigation projects in developing countries, designers are not responsible for their construction. This presents a major problem since the final designs often dictate the extent of labour that can be effectively utilised. Once the design is finalised, the opportunity to manoeuvre between the mix of labour and machinery is largely reduced. Changing important aspects of design during the construction phase to use more labour will not only significantly increase the over-all cost of the project but also will unduly lengthen the construction time. Such changes contribute to an inefficient and often counter-productive construction process.

If employment generation is accepted as an essential objective of irrigation development, it is necessary to start from the design stage, and adopt a design that is more amenable to labour-based construction. This would become clear if certain components of an irrigation work are considered.

A major component of any large-scale irrigation project is the dam, which could be concrete, masonry, earth-fill or rock-fill. If the design stipulates a concrete dam, machine-intensive methods are more likely to be used. This is because processes like mixing of concrete, placing of concrete and other allied operations have to be mechanised so as to maintain a high rate of progress. Furthermore, operations like cooling of aggregate, cooling of concrete and surface cleaning by sand-blasting are not easy to carry out by manual labour in high dams. For smaller projects, or project components, some intermediate technology using a larger labour-mix could be adopted, if desired.

In contrast, there is more scope for labour for earth and rock-fill dams, but even then machinery may have to be used for larger structures, especially if rapid completion of the project is considered to be essential. However, by adopting appropriate labour mobilisation and management processes, it is still possible to construct large earth and rock-fill dams, even if completion time is a constraint. Labour management in such cases would have to be highly sophisticated. Experiences from several construction projects in China like the Haiho confirm this observation (Chin, 1975; Nickum, 1978).

Similarly, considerable scope exists for extensive use of labour for construction of masonry dams. Next to earthwork, stone masonry can utilise manual labour most effectively in the entire field of construction activities. Mechanisation, except for mixing of mortar, is neither essential nor necessary. Accordingly, if the designers stipulate a stone masonry dam rather than a concrete one, labour-based construction can be used extensively and effectively.

A good example of modifying designs to make a project more conducive to labour-intensive construction is the Tanchiangkou multi-purpose project in Central China (ILO, 1977; Anon. 1974). A coffer dam had to be built to clear the bed for the building of the main dam on the Hanchiang River. The original plan envisaged the use of more than 1,000 tons of steel plate piles but this was replaced by a coffer dam with earth, sand and stone. This modification enabled the authorities to build the 1,300 m long and 13 m high coffer dam by labour-intensive methods in six months.

The scope for the use of labour-intensive technology in tunnelling, especially through rocks, is somewhat limited. It should, however, be pointed out that while the need for unskilled and semi-skilled workers is somewhat limited for such specialised purposes, the need for professional and skilled labour increases, and becomes much larger than expected for corresponding "normal" projects. But in terms of total number of workers used, such projects would have much lower requirements than otherwise necessary. While this can be accepted as a general rule, there are cases when such a supposition is not valid. For example, for the tunnelling works of the Beas Project in India, highly labour-intensive methods were used to excavate difficult sections of the tunnel in preference to highly mechanised techniques (Padhye, 1979). Another major example is the Red Flag Canal Project in China which diverted water from the Changho River in Shansi Province to Linshein county. The main tunnel was 616 m long, 6.2 m wide and 5 m high. According to Saxsena (1978), holes were drilled by chisel and hammer without jack-hammers and compressors. The workers "hung on ropes from mountains to excavate the canal on almost vertical slopes of the mountain. They blasted the tunnels without the aid of machines". A brigade of 300 men and women worked for 16 months to complete the project.

Similarly for canals, design specifications could predetermine the labour-machinery mix for construction. For example, it is much easier to use labour-based techniques for excavating shallow and wide canals in comparison with deep and narrow ones. So far as alignments are concerned, labour-intensive processes are more conducive for canals having shallow cuts with low embankments rather than deep cuts and high embankments.

Canal lining is another important operation where manual labour can be used effectively. The process involves preparation of the sub-grade, lipcutting of the sides and laying of concrete slabs, stone slabs, bricks, and dressed or undressed stones, whichever is economic and readily available. In India, the canal lining often consists of laying two layers of 1 1/2 inches thick tiles with 1/2 inch cement plaster under each layer. Large numbers of manual labourers can be used for the construction of such linings.

With respect to land drainage works, shallow open drains can be excavated manually by using hand tools. If, as in certain instances, the drains are deep and water tables are high, machinery has to be used for excavation.

It is thus evident that whereas considerable emphasis is often placed on the possible use of labour-based techniques during the construction phase of large scale irrigation works, the real pay-off will occur if such considerations are given at the design stage, so that the designers consciously make a choice to mould their designs in order to increase the employment potentials of the projects, consistent with the criterion of economic efficiency.

IV. PROJECT PLANNING AND MANAGEMENT

Project planning and management is one of the most important dimensions for successful completion of the projects. Since labour-based construction requires large numbers of workers, managers must be experienced in the recruitment and organisation of labour. If project managers are not properly trained, the productivity at a construction site is likely to be low.

There are many aspects of project planning and management, and the important dimensions are discussed herein.

Availability of labour: Several categories of labour are required for the construction of large-scale irrigation works. These can be classified under the following five broad headings:

(i) Professional: This includes primarily all types of engineers - senior, assistant and junior - economists and administrative personnel. They normally tend to be staff members of regular establishments, either State or Central.

(ii) Supervisory: These are primarily field workers, such as foremen, chargemen, etc., directly involved with the actual construction of the projects.

(iii) Skilled: This includes masons, carpenters, stone-cutters, drillers, mechanics, operators of various machines used for construction processes, etc.

(iv) Semi-skilled: Within this category are helpers, laboratory attendants, pump attendants, cleaners, etc.

(v) Unskilled: This category includes workers not having any special skill, and are primarily manual labourers. They tend to be mostly engaged in earth-work, carrying mortar, concrete or other materials, etc.

The bulk of labour employed in any large-scale irrigation project in developing countries belong to the unskilled category, and accordingly in terms of total employment creation, it is the most important sector to be considered. Consequently, in a few instances where studies have been made on the employment potentials of the irrigation sector, all the initial emphasis has been placed on the assessment of unskilled labour (Ministry of Agriculture and Irrigation, 1978). From an analysis of the Indian statistics, it can be observed that the average number of unskilled workers in various large-scale irrigation projects for the 1976-77 season varied from 1,000 to 2,500 per crore of rupees of investment, depending upon the type and nature of work.

Table 10 provides information on the peak strength of four different categories of labour - supervisory, skilled, semi-skilled and unskilled - during the year 1976-77 at some major irrigation projects in India. No information is available on the number of workers under the professional category, presumably because they were already employed by the State and Central institutions on a permanent basis, and thus these positions would not constitute the creation of "new" employments. Furthermore, the number of workers in this category will not be very high compared to other categories of personnel.

Availability of an appropriate labour force, both skilled and unskilled, at the time they are necessary and in required numbers, is evidently an important criterion which influences the final decision to adopt labour-intensive construction technology. The availability of labour depends on a variety of factors, among which are financial incentives, location of the project, climate, availability of housing and other facilities for workers, regional considerations like languages, food habits, etc. The demands for trained manpower could be high in certain developing countries, and thus they may not be easily available. Similarly, most of the unskilled workers tend to be from the agricultural sector, and thus shortage of labour often occurs during harvesting and planting seasons, even though wages offered are quite remunerative. Furthermore, in countries like India, many workers refuse to move from a labour-surplus to a labour-shortage region because of territorial or regional considerations (Padhye, 1979).

Table 10: Peak categories of labour in irrigation projects, India, 1976-77

Projects	Cost in crores[1] of rupees	Peak strength of workers			
		Supervisory	Skilled	Semi-skilled	Unskilled
Kadana Reservoir	76.35	528	968	1 265	7 000
Jawaharlal Nehru Canal	72.77	551	1 299	1 290	14 549
Sutlej Yamuna Linx Canal	90.00	142	421	510	8 576
Hemavathy	128.00	928	1 310	2 958	21 415
Jayakwadi Stage I	74.36	470	462	267	40 197
Stage II	78.25	460	355	770	22 550
Upper Penganga	84.48	37	30	25	6 410
Rengali Dam	57.93	226	1 302	1 232	5 258
Beas Sutlej Link	332.93	3 115	11 651	2 076	19 771
CAD Rajasthan Canal	98.00	168	2 854	1 984	23 703
Gandak	91.50	200	225	1 300	9 100
Sarda Sahayak	314.85	2 700	3 150	18 000	126 000
Kangsabati	65.89	515	779	1 838	29 956

Source: Ministry of Agriculture and Irrigation, 1978.

[1] Crore = 10 million rupees

In terms of the number of employment opportunities available, the important category of labour, as briefly mentioned earlier, is unskilled workers. The requirements, depending on the project being considered, vary from year to year, and also from one month to another during any year, depending on a variety of factors, including design and construction schedules, climate, labour unrest, etc. The daily number of maximum and minimum labour engaged, and the annual averages (based on 25 working days per month) for the Tawa Project, India, are shown in table 11 (Hiremath, 1979). Table 12 shows peak labour strength, man-days and financial outlay for the Sarda Sahayak Project, India (Mishra, 1979). Similarly, the monthly average number of workers employed for the construction period of 1966 to 1977 for the Idduki Project, can be seen in figure 3. Figure 4 shows the distribution of labour in the different component works of Idduki Project as well (Darwin, 1979).

One of the major management problems is the seasonal variation of labour availability (Morss, 1976; Sagardoy, 1976). It has been estimated that as many as 150 million peasants are mobilised each year in China, during the slack farming season of the winter, to work on "water conservancy and farmland capital construction" projects (Nickum 1979). These workers cannot be considered as "surplus labour" in the traditional sense, but their utilisation in irrigation construction projects creates a difficult management problem because of their seasonal availability in such large numbers.

Table 11: Yearly maximum, minimum and average labour used in Tawa Project, India

Year	Daily labour engaged		Annual average (12 months of 25 days)
	Maximum	Minimum	
1969-70	14 511	12 540	For three months only
1970-71	18 955	2 292	10 902
1971-72	15 416	2 607	9 152
1972-73	29 929	2 614	13 986
1973-74	32 369	4 165	16 006
1974-75	35 342	6 129	19 126
1975-76	24 368	5 561	14 462
1976-77	23 291	4 850	12 750

Source: Hiremath, 1979.

Table 12: Annual statistics of man-days and financial outlay for Sarda Sahayak Project

Year	Peak labour strength	Man-days in million	Financial outlay in million rupees
1969-70	4 000	0.6	29
1970-71	6 000	0.9	36
1971-72	20 000	3.0	89
1972-73	70 000	10.5	285
1973-74	90 000	13.5	335
1974-75	120 000	18.0	441
1975-76	140 000	21.0	459
1976-77	140 000	21.0	459
1977-78	120 000	18.0	436
1978-79	80 000	12.0	303
1979-82 (Est.)	50 000	12.0	248
Total	-	130.5	3 150

Source: Mishra, 1979.

Similarly in many irrigation projects in developing countries, labour availability - especially large numbers of unskilled workers - is restricted to non-agricultural seasons only. This is primarily due to two reasons. First, the workers prefer to continue farming and/or obtain employment as agricultural labourers, partly due to necessity and partly due to tradition. Second, at the time when agricultural labour demand is the highest, that is the monsoon season, the construction activities have to be reduced due to climatic conditions. Accordingly, in terms of labour utilisation over an entire year, agricultural and construction activities complement each other remarkably well in countries like China, India or the Philippines.

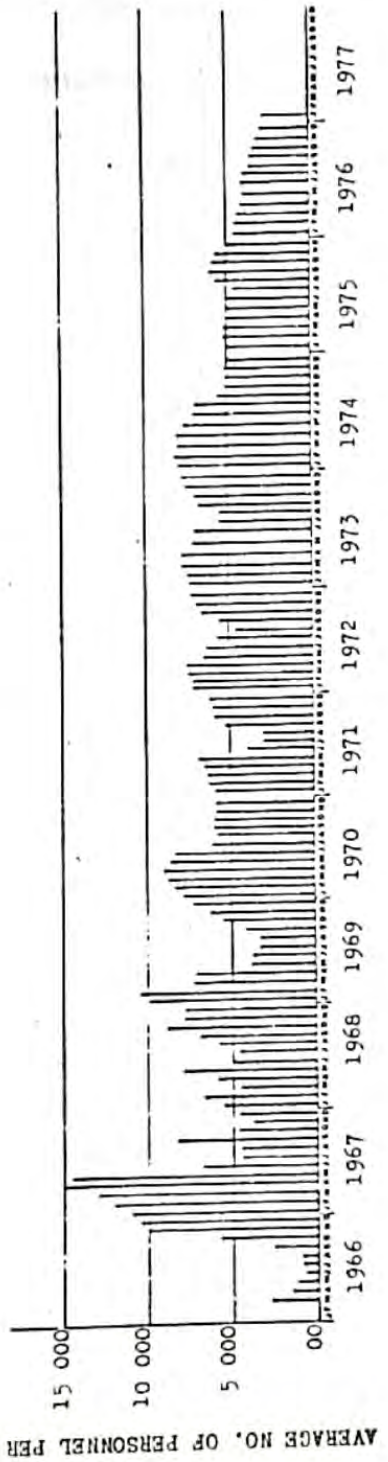
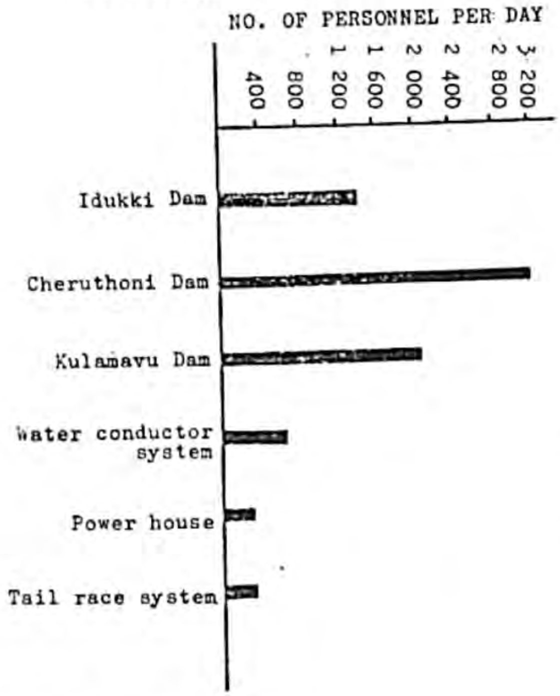


Figure 3: Labour employed for Idduki Project, India, 1976-77

Source: Darwin, 1979.

Figure 4: Distribution of labour in component works of Idduki Project, India



Source: Darwin, 1979.

The seasonal fluctuations in the use of labour in some selected irrigation construction projects is shown in table 13 (Ministry of Irrigation and Agriculture, 1978). Studies carried out on labour availability along the Indus Super Highway indicate that 40-50 per cent of workers employed in the agricultural sector during the peak season became redundant during the slack season (ILO, 1977a).

Since the number of workers required for construction of large-scale irrigation works is high, it has always been somewhat difficult to satisfy the labour requirements locally (ILO, 1977). For the Indus Super Highway study mentioned earlier (ILO, 1977a) it was found that about 65 per cent of workers available during the peak harvesting season and 41 per cent of workers available during the slack season were prepared to live in camps, and could be recruited to work outside their districts. Furthermore, groups of labourers exist in Pakistan who travel all over the country working in construction sites. These gangs and workers available locally were expected to provide the necessary labour for the construction of large-scale works.

During the construction of the Aswan Dam in Egypt, analysis by Naguib (1966) of manpower planning indicated that labour requirements during the initial stages did not appear to be a problem. Even though supply seemed to be abundant, "at the beginning of 1964 none knocked on our doors". Contractors were forced to transport labourers from neighbouring governorates to the construction sites. Similarly, for the Bhakra-Nangal Project in India, as much as 60 per cent of workers had to be imported from other provinces (Raj, 1960).

Table 13: Number of semi-skilled and unskilled workers on various projects, India, 1976-77

Project	Semi-skilled			Unskilled		
	Seasonal average				Seasonal average	
	Peak	Working	Non-working	Peak	Working	Non-working
Nagarjuna Sagar Canals	NA	540	140	NA	28 000	250
Kadana Project	1 265	1 001	652	7 000	4 152	3 174
Panam Reservoir	NA	4 452	31	NA	43 566	363
Jawaharl Nehru Canal	985	626	145	14 549	8 999	1 600
Jayakwadi Stage I	267	242	182	40 197	28 588	21 870
Jayakwadi Stage II	770	720	260	20 550	15 250	6 670
Ramial Irrigation Project	2 907	1 710	826	87 210	51 300	24 795
Rajasthan CAD	1 984	1 841	454	23 707	16 716	7 926
Kelavarapalli Reservoir	880	769	939	26 037	14 224	12 073
Gandak Project	1 300	800	600	9 100	5 600	1 000
Parallel Lower Ganga Canal	1 800	1 100	500	7 500	4 500	480
Sarda Sahayak Project	18 000	11 500	3 000	126 000	80 000	14 000
Kangsabati Reservoir	1 838	1 756	1 827	29 956	137 552	7 148

Source: Ministry of Agriculture and Irrigation, 1978.

In addition to the availability of large numbers of manual workers for labour-based construction of major irrigation works, it is essential to ensure availability of adequate animals, carts, small tools, etc. (Dreiblatt, 1972; ILO, 1977). For the Indus Basin Project in Pakistan, the animal labour component available was grossly inadequate. The peak donkey labour requirement to handle part of the programme was 30,400, but the maximum number available in the country was around 20,000. Furthermore it was not possible to assume full availability at the start of the construction. Accordingly, it was decided to use mechanical methods (Rigg, 1966).

Labour productivity: Productivity of labour varies tremendously not only from one country to another, but also from one province to another within the same country. Data on productivity of skilled and unskilled labour have now been assembled from India under the following categories:

- Skilled labour
  - Stone masonry
  - Brickwork
- Unskilled labour
  - Earthwork
    - Ordinary
    - Soft rock
    - Hard rock

Table 14 shows the range of wages for skilled and unskilled labour and their productivity under the various categories for different provinces of India. Similarly table 15 shows the productivity figures per skilled and unskilled workers per shift of eight hours from specific irrigation projects from different provinces of India. The magnitude of the variations will indicate the difficulties of generalising results on labour productivity.

Table 14: Labour wages and productivity in different India provinces (compiled from Ministry of Agriculture and Irrigation, 1978)

Province	Skilled			Unskilled			
	Wage (Rs.)	Output per capita (m^3)		Wage (Rs.)	Earthwork output per capital (m^3)		
		Stone masonry	Brickwork		Ordinary	Hard rock	Soft rock
Gujarat	6-15	0.47-3.0	0.8 -5.0	5-7	1.5-3.0	1.0-2.0	0.75-0.8
Haryana	10-18	0.05-1.14	1.7 -2.0	8-10	1.7-4.8	2.0	3.58
Kamataka	5-12	1.0 -2.0	1.0 -3.0	3.5-6	1.0-3.0	0.5-2.0	0.25-1.0
Maharastra	6-10	1.0 -2.5	1.25-3.0	3-4.6	3.25	0.5-2.0	0.25-0.3
Orissa	NA	0.25-4.0	0.3 -5.0	NA	1.0-3.0	0.3-1.0	0.2 -0.3
Tamilnadu	8.0	0.56-1.0	0.7 -1.0	6.0	2.5-4.0	1.0	0.2 -0.7
UP	15-20	1.0	1.0 -1.25	5.0	2.0	0.75	0.5
W. Bengal	7.0	0.8 -1.0	1.1 -1.4	5.0	2.6-3.5	1.1-2.0	0.6 -1.0

So far as stone masonry is concerned, output varied from a low of 0.05 m^3 to a high of 4.0 m^3 per skilled worker. One of the main reasons for such a high variation is due to the type of work being carried out. For example, output is high for random rubble or undressed masonry, but much lower for hard stone masonry. Furthermore, lift and lead for different projects affect the final output. Generally, the average output for stone masonry was between 1 to 2 m^3 per day. The productivity for brickwork varied from 0.3 m^3 to 5 m^3 per day, with an average in the region of 1.0 to 2.0 m^3 per day. The lower figure of 0.3 m^3 is certainly very low, and is somewhat difficult to explain. The daily wages paid to the masons varied from a low of Rs. 5.00 to a high of Rs. 20.00

The daily output per unskilled worker for earthwork varied from 1.0 to 4.0 m^3, with an average of 2.0 to 3.0 m^3 per day. The productivity was naturally less for soft rock 0.3 m^3 to 2.0 m^3, and even less for hard rock, 0.2 to 1.0 m^3. For earthwork, productivity depended on a variety of factors, inter alia, climatic conditions, soil type and moisture content, lead and lift of specific projects, and health and other prevailing environmental conditions. It should be noted that because of the differing conditions under which such data were collected, inter-comparisons of the Chinese and Indian data are not possible.

Table 15: Labour productivity data from Indian irrigation projects

State and project	Output per person per shift of eight hours					Notes
	Skilled		Unskilled			
	Stone masonry (m^3)	Brickwork (m^3)	Earthwork (m^3) Ordinary	Soft rock	Hard rock	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Andhra Pradesh						
Nagarjuna Sagar	4.00[(1)]	1.00	2.80-3.00	0.67	0.35	(1) With 1 assistant per day
Gujarat						
Damanganga Res.	0.47	5.00	3.00	2.0	0.8	
Kadana Res. Project	3.00[(2)]	-	3.00	2.0	0.75	(2) With 1 set of Chawalis, 3 mortar carriers, 1 unskilled worker
Haryana						
Jawaharlal Nehru Canal	0.05-0.15	1.80	4.80	-	3.58	
Sutlej Yamuna Link Canal	1.14	2.00	2.00	2.00	-	
Karnataka						
Amarja Project	1.00	1.25	1.00	0.50	-	With helper
Bennithora Project	1.00	1.25	1.25	0.60	-	With helper
Karanja Project	2.00	3.00	3.00	2.00	1.00	
Tungabhadra Left Canal	1.10	1.60	1.50	0.90	0.70	
Upper Krishna Project 1	1.00	1.50	3.00	1.50	1.00	
Orissa						
Ramial Irrigation Project	4.00	5.00	3.00	0.30	0.26	
Upper Kolab Project	0.3-0.6	0.6-0.7	1.0	0.5	0.2	
Tamil Nadu						
Pambar Project	0.8-0.9	0.9-1.0	4.0	1.0	0.7	
Sathanur RB Canal	1.00	1.00	3.0	1.0	0.2	

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Uttar Pradesh						
Sarda Sahayak Project	up to 1.00	1-1.25	2.0	0.75	0.50	
West Bengal						
Barrage and Irrigation System, DVC	0.90(3)	1.28(3)	3.17	1.80	0.68	
Kangsabati Project	1.00(4)	1.00(5)	2.57	1.13	1.00(6)	(3) With 1/2 semi-skilled, 1 1/4 unskilled
Mayurakshi Project	0.90(3)	1.28(3)	3.17	1.80	0.68	
Teesta Project	1.00(3)	1.42(3)	3.52	2.00	0.75	
U. Kangsabati Project	0.80(3)	1.10(3)	2.80	1.60	0.60	(4) With 2 unskilled
						(5) With 1 1/2 unskilled
						(6) With 1/30 skilled, 1/6 semi-skilled, 5/6 unskilled labour

Source: Ministry of Agriculture and Irrigation, 1978.

Labour productivity can be improved by taking appropriate measures. For the Sarda Sahayak Project in India, the following measures were specifically taken to improve productivity (Mishra, 1979):

(i) advance planning of work so that specific tasks can be assigned to each worker, or a group of workers, immediately on their arrival at the work site;

(ii) provision of transportation to take staff and labour as close to the construction site as possible;

(iii) earlier arrival of supervisory and field staff at the site so that preliminary details can be worked out to ensure timely commencement of work;

(iv) immediate availability of necessary tools for the workers;

(v) convenient location of cement and tool sheds, stockpiles of sand and gravel, etc., so that time spent in transporting them is reduced;

(vi) flexibility in scheduling so that workers could be engaged on other subsidiary works, if the main work is to be temporarily suspended due to power failure, breakdown of water supply or accidents;

(vii) daily review of work and analysis of the problems and difficulties encountered so that they are resolved immediately; and

(viii) availability of rest-sheds, portable drinking water, toilets and medical facilities.

In addition to the measures taken above for the Sarda Sahayak Project, analyses of past results of irrigation construction projects indicate that the following issues are likely to contribute to productivity improvement.

(i) Financial incentives: It is useful, especially for skilled and unskilled workers, to relate wages to outputs. This could be done by piece-rate work or task-work system. Such a payment system serves as an inducement to increase productivity (Ministry of Agriculture and Irrigation, 1978).

(ii) Strict enforcement of labour laws and contractual obligations: For good labour relations, it is important that workers are aware of local labour laws, and that they are strictly enforced. Contractual obligations, like prompt payment of fair wages, provision of acceptable living conditions, availability of recreational facilities, etc., should be promptly met.

(iii) Training of supervisory staff: Productivity can be increased if the supervisory staff are capable of motivating labour, aware of organisational and operational aspects of labour force and familiar with scientific management of various operations associated with the construction of large-scale irrigation projects. These can only be achieved if the supervisory staff are properly trained.

(iv) Provision of medical facilities: If possible, medical facilities should be provided free of cost to the workers, both at the work site and at labour colonies. If not, such facilities should be provided at a low flat rate.

(v) Subsidised rations: During the construction of irrigation projects, which are not near centres of population, appropriate infrastructural facilities do not often exist. Accordingly, it is important to provide subsidised rations to the workers, or arrange to develop a food co-operative, so that everyone can obtain nutritious food at prices they can afford. Alternately, as is the case in many parts of India, "fair price shops" should be established so that the workers are not economically exploited.

(vi) Appointment of a labour officer: A labour officer should be exclusively available to look after the interests of the workers. His role should be somewhat like an ombudsman, and he should also be in a position to assist the workers in obtaining continued employment, if and when labour becomes surplus on the project.

V. CONSTRAINTS FOR USING LABOUR-BASED CONSTRUCTION

While the use of labour-intensive technology is desirable in many instances, it is best to be aware of some of the problems and limitations associated with their utilisation, so that disadvantages can be minimised by anticipating them and then by taking appropriate countermeasures. Some of the major problems and limitations are discussed below.

(i) Labour availability and suitability: It is not always possible to recruit labour, since all workers available may not be suitable for the work to be carried out. Often a versatile labour force is required, and it may not be possible to recruit such a complete force.

Skilled labour is sometimes difficult to find. For example, for the Mayurakshi Reservoir Project, masons were available, but they were not of the right type (Aich, 1979). Hence, for boulder masonry, no trowels were allowed at the construction site so that stone boulders were placed on the mortar and not mortar on the stones. Local masons were unable to carry out dressing of granite-gneiss stone for face blocks. Accordingly a self-containing group of workers, capable of carrying out the operation, had to be imported from South India to West Bengal. The team came with their own blacksmiths, cutters, priests for their religious functions and even undertakers for funerals when necessary.

Labour recruitment during harvests and religious festivals could pose serious constraints. Accordingly the possible impacts of such factors have to be incorporated in construction schedules, if delays and cost increases are to be avoided.

(ii) Rate of construction: Time available for completion of construction of irrigation works is an important factor which could have a decisive bearing on the mix of labour and equipments to be used in a specific project. For very large concerete dams, having tight construction schedules, machine-intensive technology tends to be normally preferred. However, so far as large masonry, earth and rock-fill dams are concerned, labour-intensive methods, complemented with light machinery, have been successfully used to complete construction within scheduled time periods, both in China (Henle, 1974) and in India (Padhye, 1979). There are several such examples of masonry dams in India, among which are the Nagarjunasagar Dam (Andhra Pradesh, 125 m high), the Bhatsa Dam (Maharastra, 89 m), the Mahi Weir (Gujarat), the Mahi Bajajsagar Dam (Rajasthan, 68 m), the Kadana Dam (Gujarat, 65 m), the Sharavati Dam (Karnataka, 62 m) and the Tawa Dam (Madhya Pradesh, 58 m). If the design and construction phases of these dams are analysed carefully, it becomes evident that whenever the dams were to be constructed within a strict time schedule, there was a discernible trend in increasing the use of machines. It should, however, be noted that when these decisions were made, the costs of the machines and their operational expenses were much less than they are at the present, and consequently costs of the use of machines compared favourably with labour under the prevailing circumstances. With higher costs of machines at present, it is possible that the economic comparison may have changed somewhat. But the fact still remains, if labour-intensive construction is envisaged, then an extended time schedule should be anticipated for large-scale irrigation works under normal circumstances (Carruthers and Mountstephens, 1978).

(iii) Supervision: If a large number of unskilled and semi-skilled labourers are to work efficiently and effectively, they must be properly supervised. Hence, a large number of trained and experienced supervisors are necessary for the construction to proceed smoothly and on schedule.

(iv) Quality control: Associated with the question of supervision, is the problem of quality control. If a piece-work system is to be used, a well organised and reliable quality control system has to be devised to check each item. Such a continuing system often becomes a source of strain to the supervisory staff. Also, since a large number of workers are involved, the quality of work may not be uniformly good. Accordingly, it may be necessary to accept lower standard of construction in certain areas, where they are not critical.

(v) Labour unrest: The presence of a large number of workers could result in frequent strikes, go slow or work to rule tactics or labour agitation. Such developments could disrupt work schedules, and contribute to the delay in completing the project and also increase its cost.

For the Idduki Project in Kerala, India, almost all provincial political parties had their supporters, among the workers, and the external interference started from the very beginning (Darwin, 1979). All factions attempted to expand their spheres of influence, and this contributed to occasional violence. Altogether 2.88 million man-days were lost due to labour strikes.

(vi) Religion and food: The religious and food habits of the workers could differ. These requirements have to be met if the labour force is to be kept contented.

(vii) Use of foreign expertise: In many developing countries, foreign consultants and contractors still plan, design and construct irrigation projects. In the majority of these cases, the foreign firms are not fully familiar with the prevailing social and economic norms of developing countries, and accordingly they often use criteria which are based on experiences and knowledge gained in the advanced industrialised countries. The planning and design emphasis tends to be on capital-intensive rather than labour-intensive techniques. Labour-oriented designs significantly influence contractors to use more labour, but mere grafting of increased labour component as an after-though is unlikely to be very effective.

(viii) Interdepartmental co-ordination: Large-scale irrigation projects are normally under the jurisdiction of the Ministry of Irrigation or Ministry of Water Development. Such ministries, however, are not responsible for job creation, which is usually undertaken by the Ministry of Labour. Accordingly it is not exactly unusual to find that officials of the Ministry of Irrigation give lip service to employment generation, and officials of the Ministry of Labour are either not fully aware of the employment potential of irrigation construction projects or not sufficiently well-informed as to how to proceed to maximise employment potential from such projects. Often there is not much co-ordination between the two ministries, and sometimes they could even be in conflict.

(ix) Prestige: It is not unusual to find many engineers in developing countries who consider project design as a matter of prestige, and thus tend to use most sophisticated design practices. Capital-intensive designs are often accepted to be "progressive" and scientific, but labour-intensive technology is considered to be backward and unscientific.

(x) Child labour: A negative aspect of labour-intensive construction projects is the utilisation of child labour. Use of children as part of the labour force is not only violation of international conventions[1] but also ensures that they remain illiterate due to lack of schooling. In most countries there are appropriate legal regulations in preventing child labour; what is necessary is their enforcement.

[1] The Minimum Age Convention, 1973, adopted by the International Labour Conference, provides that the minimum age for admission to employment shall not be less than the age of completion of compulsory schooling and in any case not less than 15.

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