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RIVER VALLEY PROJECTS IN INDIA: THEIR DIRECT EFFECTS*

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The present article advances a tentative framework for the analysis of the direct effects which the irrigation component of river valley projects may have on the structure of agriculture in underdeveloped countries. The focus of attention is on the impact of river valley projects in the agricultural economy within the context of the total development effort of which these projects are usually a part. In its quantitative aspects the analysis makes use of Indian data; in its broader methodological implications and qualitative aspects the analysis would seem to transcend particular cases and apply to other underdeveloped areas as well.

The term direct effects covers the repercussions which a perennial supply of water is likely to have on the structure of farm production in the area immediately adjacent to and affected by the project. In addition,to these direct efforts there are various indirect or secondary effects of river valley projects which are reflected in changes in the structure of industries (including distribution) in a wider area and which can be traced back to the changes in agricultural production. Both the direct and indirect effects of irrigation can be distinguished at least conceptually from the socio-cultural impact which river valley projects may have on world outlook and institutional arrangements. In the present article, however, attention will be focussed on the direct effects of irrigation.

I

The practical and theoretical importance of a general conceptual framework for the qualitative and quantitative analysis of the effects of river valley projects requires hardly any elaboration. Economic planners in underdeveloped countries are asking with increasing insistence for suitable investment criteria, designed to permit a rational judgment[1] of alternative projects. Such criteria

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1. We are using the generic term "judgment" rather than the traditional concepts of choice, evaluation, and measurement in order to avoid any misunderstanding and avert any allusion concerning the quantitative precision that can be hoped for in the assessment of social goals and the process of decision-making in national economic planning.

would have to throw light on the as yet unsolved and open questions of national economic planning that are related to the ranking of river valley projects as compared with other social overhead investments, the establishment of priorities among alternative projects, the determination of the relative public expenditure level and hence the proper size for each project; the allocation of costs to the different but joint purposes of the project, and lastly the selection of the administrative measures and subsidiary investments which would secure the prompt and optimum use of the new capital goods and services. Obviously, the common prerequisite for the elaboration of rational investment criteria is an adequate and comprehensive knowledge of the typical (both actual and potential) effects of the various component parts of river valley projects.

While there is no scarcity of empirical data and theoretical studies on the subject, a satisfactory solution of the difficult problem raised by the aforementioned issues still seems to escape us. Indeed, the authors of a rapidly increasing literature on benefit-cost calculations in connection with river valley projects seem to have no illusions concerning the comprehensiveness and validity of their criteria. In fact, it is one of the merits of these studies[2] to have made explicit some of the assumptions which underlie the calculations of investment criteria in terms of benefit-cost ratios. Among these assumptions are the following: (1) that prices reflect the true opportunity costs of resources (which they do not in underdeveloped countries which are on the verge of emerging from a long period of stagnation and are in a process of economic and social transformation); (2) that human resources are fully employed (which is not the case in underdeveloped countries which carry with them much open and disguised unemployment); (3) that the intangible benefits are not so large that they outweight the benefits that can be measured in monetary terms (which may hold neither for developed nor underdeveloped countries); and (4) that problems of equity (e. g., equalizing the opportunity of economic growth as between different regions and redistributional reforms in general) can be ignored, which, while perhaps tenable for developed countries where problems of equity and redistributional reforms can be taken care of by countervailing tendencies made possible by the democratic process, would be equivalent to assuming away some of the most important obstacles to economic growth and social change in underdeveloped countries.

Indeed, all benefit-cost studies seem to be focussing attention on the allocation problem at the expense of the question of whether and what kind of

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2. See on the following: Otto Eckstein, Water-Resource Development, Cambridge, Mass., 1958, pp. 280-281; Symposium on Determination of Costs and Benefits of River Valley Projects, 1953, Central Board of Irrigation and Power, New Delhi, 1954; H. W. Singer, "Development Projects as Part of National Development Programmes", United Nations, Formulation and Economic Appraisal of Development Projects, I, New York, 1951; W. Galenson and H. Leibenstein, "Investment Criteria, Productivity and Economic Development", Quarterly Journal of Economics, August 1955, pp. 343-370; V. V. Novozhilov, "On Choosing between Investment Projects", Interntaional Economic Papers, 1956, No. 6; Proposed Practices for Economic Analysis of River Basin Projects, Report of the Federal Inter-Agency River Basin Committee, Subcommittee on Benefits and Costs, Washington, 1950.

cumulative economic and social changes may be set in motion by river valley projects. In a fully developed country in which the preconditions of cumulative economic and social change are more or less fulfilled, this neglect of what may indeed be taken for granted is perhaps justifiable. In an underdeveloped country where "the natural play of forces" has long tended toward stagnation, the use of purely monetary benefit-cost calculations as investment criteria raises more questions than can be answered at the present time. For instance: will the highest benefit-cost ratio automatically assure the highest real and social rate of return? Will the highest rate of return and profitability based upon the pattern of demand that emerges from free consumers' choices necessarily guide us to those investment outlays which maximize the rate of growth? Finally, how can benefit-cost ratios take into account the fact that investments with long periods of gestation and high capital intensity in all associated production functions may have a lower productivity in the short-run and hence a high capital-output ratio which might disappear if a longer period of time is allowed in measurement?[3] As soon as it is realized that the process of economic growth in order to become cumulative must also be a process of social change and cultural transformation, it becomes clear that benefit-cost ratios, while not without considerable significance in evaluating public investments in fully developed countries, may be much less relevant as investment criteria for underdeveloped countries.

In the present article we start from a somewhat different theoretical framework than that which underlies the calculations of benefit-cost ratios. In contrast to the theoretical framework which assumes a tendency toward self-stabilization, we accept the principle of circular or cumulative causation which Myrdal first developed in connection with the analysis of the Negro problem in the United States and which he has recently applied to the study of the economic process in underdeveloped countries. This principle seems to throw light on the emergence, continued existence, and even growth of regional inequalities by focussing attention upon the interaction of what are really inseparable economic, political, and cultural factors. Like the well-known cumulative interaction of poverty, ignorance, and disease, the social system, under the impact of the whole range of economic and non-economic factors, "is by itself not moving toward any sort of balance between forces but is constantly on the move away from such a situation. In the normal case a change does not call forth countervailing changes, but, instead, supporting changes, which move the system in the same direction as the first change but much further".[4]

In contrast to the earlier conceptual framework which views the social process (or at least the conceptually separated "economic" process) as subject to essentially self-sustaining (i.e., countervailing) forces which tend to some theoretically definable and determinate stable position, the principle of

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3. W. Rostow, "Trends in the Allocation of Resources in Secular Growth", in L. H. Dupriez, ed. Economic Progress, Papers and Proceedings of a Round Table Held by the International Economic Association, Louvain, 1955, pp. 367-382.

4. G. Myrdal, Rich Lands and Poor, New York, 1957, p. 13.

cumulative causation makes it possible to account for the practically more relevant tendency of circular stagnation in underdeveloped countries. What has to be understood above all are the causes which led to cumulative processes of stagnation and regional inequalities. And these processes cannot be fully interpreted as long as the so-called economic are seen in isolation from the so-called non-economic factors.

This is not the place to develop the concept of cumulative causation in greater detail[5] and with particular reference to regional inequalities in underdeveloped countries. Suffice it to make explicit the scientific and methodological implications of the principle of cumulative causation for a realistic study and ultimate appraisal of the effects of river valley projects. Perhaps the first and most important implication is that river valley projects must be viewed in their relation to the total economic situation and development plan of the country under consideration. What is relevant in this connection must be determined in each case by the effect and potency of an impulse (such as irrigation and power) to bring about changes in the social system in the direction of cumulative expansion. This does not mean that it is necessary or even desirable to study the process of cumulative change in its totality. The strategy of scientific analysis calls for a reduction of any problem under discussion to manageable proportions and for the introduction of relevant distinctions between the different factors at work. While we have will to divide the process under study according to these methodological requirements, it will be necessary to keep in mind at all times that the changes set in motion are interconnected. More than this, it is important that the effects be traced and described not only qualitatively but also quantitatively. Ideally the complete and truly scientific solution of the problem would indeed require an "interconnected set of quantitative equations, describing the movement and the internal changes of the system studied under the influences which are at work. That this complete, quantitative and truly scientific formulation is far beyond the horizon does not need to be pointed out".[6]

In the meantime it will be helpful and necessary to provide a rational framework capable of identifying as completely as possible the relevant and strategic functional relationships which river valley projects are likely to set in motion. What the planner must know and the social scientist wants to discover are the effects which a given supply of water in a dry area may have on the structure of farm production. What will be the effects of the new structure of production on the rural subsistence economy? What are the new input or investment requirements? What are the probable expenditure patterns which the new output and the additional farm income make possible? What additional yields can be expected? More specifically, which administrative arrangements and subsidiary public investments will be called for in order to assure the optimum utilization of the new capital equipment and through it the maximum economic advance of the region? Equally important, what are the potential negative

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5. For a fuller treatment see Myrdal, op. cit., Chas. 2-8; and The American Dilemma, The Negro Problem and Modern Democracy, Appendix 3, "A Methodological Note on the Principle of Cumulation", New York, 1944, pp. 1065 ff.

6. Myrdal, Rich Lands and Poor, op. cit., p. 19.

effects of supplying additional water to a formerly dry area in a tropical country? And finally, what will be the long-run impact of the new structure of production and the new farm economy on the cultural values and behavior patterns in the underdeveloped area? It goes without saying that some of these relationships are less accessible to scientific analysis than others. However, a rational framework of investment planning calls for a comprehensive appraisal of all the effects, whether immediate or potential, which river valley projects are capable of setting in motion. Without such an appraisal the planning authorities are not likely to develop a realistic strategy of administrative controls designed to assure the greatest possible benefits from the public investment.

From the foregoing it must be clear that the complicated processes of circular interrelationships which multi-purpose projects are capable of setting in motion can be analyzed and appraised only in real terms. That is to say, we must abandon the hope of analyzing the circular process in terms of a single criterion of market values and must instead face the much more difficult task of finding a way to appraise its effects in terms of criteria that are adapted to the task of measuring the cumulative process of growth in its various manifestations. Ultimately this may be possible only in terms of a technical standard that measures improvements in "the economy of means" in physical terms rather than in terms of the more comprehensive but somewhat formal test of the efficiency of the entire allocation problem within the economy as a whole. No doubt an underdeveloped country can ill afford any inefficiency (waste) in the allocation of its limited resources for its competing objectives. But in the absence of any precise and substantive knowledge of the benefits obtainable from the whole range of alternative investment outlets (e.g., improvement of agricultural technology and farm management, reform of farm credit, widening of internal and foreign markets, administrative and political reforms, wider educational opportunities, and changes in land tenure arrangements), we must be satisfied with an appraisal of the development process in terms of relationships between physical quantities. Such relationships can be expressed in terms of output per input (production per factor) or in terms of input per output, in which case they measure the use or "consumption" of required factor per unit of output. In either of its two forms productivity data are ratios without upper limits that are capable of showing the progressive improvement from period to period. What makes productivity a particularly comprehensive test of the growth process is the fact that its increase depends upon many causative factors. Technology and equipment must combine with greater skill and the capacity to innovate, as well as greater equality of opportunity, higher industriousness, and new forms of human relations, before it is possible to make a significant dent in the low level of productivity (particularly agricultural productivity) of most underdeveloped countries. It is precisely because productivity depends upon economic and social changes that improvements in productivity provide not only the most comprehensive test but also the major goal of the underdeveloped world. Unless productivity is rising in the affected regions from year to year, we cannot truly speak of a successful river valley project.

Finally, a descriptive analysis of the long-run effects of river valley projects would gain in perspective if it could take full account of the conditions that existed during the last decades prior to the transition to irrigated farming. Ideally, this would require a survey of the region designed to convey a picture of the available resources and their use; principal crops and output; the use of

manure and fertilizer; crop patterns and rotation; principal occupations and employment patterns; the labor supply including major skills and percentage of unemployed; the pressure of population on land including birth, mortality, and morbidity rates; the financial resources of the cultivators; administrative arrangements and their relative effectiveness; the extent of social services such as medical care and education; and the frequency and extent of famines and floods including an indication of the loss of public revenues due to the suspension of land revenue collections, as well as of the major features of socio-cultural backwardness and deficiencies. Indeed, for all practical purposes of tracing and evaluating the effects of a given project, it would be important to conduct a series of benchmark surveys of the socio-economic process not only before and after completion of the project but also during its construction.

In the absence of such comprehensive surveys, we must be satisfied to base our analysis upon statistical data capable of documenting and illustrating the various repercussions that have been selected for detailed treatment. We are aware of the fact that this procedure may introduce a bias into our analysis. The available data pertaining to older irrigation areas may not be representative of the effects which additional land brought under irrigation in other areas may have. It is not possible to say whether the extension of irrigation farming to new areas would give rise to a greater or smaller increase of output and a more or less pronounced change in the structure of farm production. As pointed out later, these effects depend upon many factors.[7] All that can be said here is that statistical data in underdeveloped countries are relatively sketchy and uneven; that the data used are the only ones available; and that in view of the fact that the data pertain to conditions in which for the most part there was no deliberate plan for many of the subsidiary investments called for by irrigation farming, they may underestimate rather than overestimate the direct effects of irrigation.

II

The strategic significance of irrigation in India's development effort derives from the fact that the average rainfall for most of India is low and subject to great variations. This inadequacy and unevenness of rainfall gives rise to recurrent crop failures in some areas and keeps other regions desert areas. Indeed, India's whole development effort must be viewed against the background of four interrelated factors which define her present economic position: recurrent acute food shortages, extreme poverty of great masses of the population, rapid population growth, and unemployment as well as underemployment. Only the first of these factors needs to be illustrated here.

Between 1948 and 1953 India imported 19.3 million tons of cereals. The average annual food shortage was 3.2 million tons. At an average cost of about Rs. 450 per ton the total cost and foreign exchange requirements due to food shortages would amount to Rs. 1.5 billion. In the absence of foreign loans (which may have to be serviced sooner or later), the prevention of general starvation and famines for large masses of the population depends upon the

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7. See below.

ability to increase the output of food. Moreover, recurrent shortfalls of food represent a continuous threat to the implementation of the industrialization effort upon which depends India's whole development effort and her ability to utilize her increasing idle manpower. It is of course true that the production of food can be increased either by improved techniques of production on land already under cultivation or by expanding the area under cultivation. India's special geographic and climatic situation, together with her rapidly increasing population, makes it imperative not to rely only on the improvement of agricultural techniques. Apart from the fact that India's success with improved techniques has been limited in the past (as judged by relatively stable yield figures), even further improvements of techniques (through greater use of fertilizer, farm equipment, and improved seeds) depend for their success upon an assured supply of water. The only dependable way of establishing a system of intensive agriculture as well as of extending the margin of extensive cultivation seems to be to provide areas which have a low and uneven rainfall with an assured water supply. This can be done only by storing the precipitation in catchment areas which have an abundant rainfall, especially in some of the higher altitudes and diverting this dependable supply of water through canals and distributaries to the areas with inadequate and variable rainfall. In short, what is required is the construction of major dams and reservoirs capable of storing and controlling the flow of important rivers and their tributaries. This is precisely what India has been trying to do under English rule as well as since Independence. In fact, this is what responsible statesmen in India seem to have been trying to do since time immemorial, to judge from the evidence of a vast network of irrigation works and inundation canals not only in the Indus valley and the region of the Jumna river but in South India as well. [8]

What are likely to be the effects of the shift from dry farming to irrigation farming in contemporary India? Any qualitative and quantitative investigation of the direct effects of the irrigation component of river valley projects must be based upon farm management data. For in the last analysis, only farm accounts and farm budgets are capable of disclosing with any degree of quantitative precision what shifts took place in input and output patterns as a result of a parennial supply of water made available by the irrigation projects. We cannot hope that our data, though derived from farm management studies, are complete and always based upon accurate observation. There are inevitable gaps in our information about farm management, particularly in an underdeveloped country like India, and it seems to be impossible to estimate the degree of the possible error in the observations upon which the respective studies are based. [9]

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8. Irrigation in India through the Ages, Central Board of Irrigation and Power, Leaflet No. 7, New Delhi, 1954.

9. Having made these general reservations we wish to point out that farm management studies have a long history in India. The Board of Economic Inquiry of the Economic and Statistical Organization of the Government of the Punjab has conducted village and farm management studies for more than thirty years. The Gokhale Institute for Politics and Economics (Poona) published its first farm survey in 1933, and the Economic and Statistical Organization of the (Central) Department of Agriculture is about to publish (1958) a series of up-to-date farm management studies for different states.

However, while it seems to be impossible to estimate the degree of the possible error, we believe that our data err in the direction of an understatement of the possible effects of irrigation farming. This is due to the fact that they relate to cases and conditions in which, for the most part, there was no deliberate plan for many of the subsidiary investments and administrative steps which must be taken in order to make the fullest possible use of the water resources made available by the development project. On the whole, perhaps with the exception of some projects in the Punjab, the policy pursued both under the British regime and in more recent years was that of relative laissez-faire. It was up to the individual cultivator to make the necessary adaptation to the new techniques of agriculture called for by the perennial supply of water. If we consider that the cultivators were often ignorant and suspicious, at least during the initial stages of the introduction of the new method of cultivation called for by irrigation, and that there were usually without adequate funds required for such subsidiary investments as the purchase of fertilizers, improved seeds, more and better foodstuffs for draft animals used for longer periods of time, it is reasonable to assume that our data are not fully representative of the total effects which a shift to irrigation farming may achieve. Against this, the economist is likely to raise the possibility of diminishing returns from additional irrigation projects. It could be argued that future irrigation projects are bound to be less productive and more costly than those that have been built in the past. Ultimately the answer to this question depends not only upon an assessment of the irrigation potential (i.e., water and land resources) as compared with the estimated food requirements of a rising population, but also upon the ability to take into consideration the effects of evolving improvements of farm techniques. Diminishing returns is a concept that comes to us from the static framework of classical and neo-classical economics. Dynamic change and technological improvements are precisely the factors which have counteracted the static phenomenon of diminishing returns in the past. In short, static economics must not be permitted to play havoc with the assessment of dynamic growth and development.

III

It is possible to view the whole process of economic and social change from the perspective of a gradual transition from subsistence farming to the production of cash crops. This is ultimately the most important economic and social change that seems to happen in response to the provision of an assured supply of water. For reasons of exposition, however, we have found it desirable to discuss first the changes in the structure of farm production which prepare the ground for the transition from subsistence farming to cash crops.

A. Changes in the Structure of Agricultural Production

Under the climatic conditions of the sub-continent of India, many crops respond to early planting, provided that there is an adequate supply of water. Hence with a perennial supply of water sowing and planting can start earlier than in areas dependent on rainfall. In fact, irrigation in the tropics makes it possible to plant and grow two or even three crops of rice. Many other crops respond to earlier planting. For instance, cotton usually cannot be grown before June; with irrigation planting can start in April. Similarly, the shift to sugar cane has

brought about far-reaching changes in production methods in areas which had no perennial supply of water before. These changes have had the effect of upsetting established patterns of activities. In an Indian village, "agricultural skill is passed on from father to son. Through time and experience the peasants develop a rhythm of production throughout the agricultural cycle in which each participant has a certain task to perform and each operation is allocated a certain date and time. The cultivation of sugar cane upset this established rhythm and it took time and thought before the new crop could be incorporated into the pattern of activities."[10]

New crop patterns--More important than the changes in the timing of sowing and harvesting with its attendant modifications of traditional activities and village life is the effect of irrigation on crop patterns. An assured availability of water makes it less risky and more profitable to switch from dry food crops to crops which require more water than rainfall makes available. These are the better quality and higher priced crops such as sugar cane, wheat, paddy, and fodder, as well as garden produce. Whereas the unirrigated farm tends to concentrate overwhelmingly on the production of food crops which in India are largely consumed locally or within the cultivator's own family, the irrigated farm can be shown to concentrate on the more valuable food crops for sale (such as rice, wheat, and sugar cane) and also may turn to fibre crops and fodder (the latter reflecting greater needs for more intensively used draft animals). Table 1 shows this change in crop pattern in the Punjab.

Table 1. Percentage of Crops Grown in Irrigated and Unirrigated Areas, Punjab, 1954-55[11]

Crop	Irrigated	Unirrigated
Food crops	55	94
Oilseed crops	2	1
Fibre crops	20	-
Fodder crops	23	5

The data are significant inasmuch as they show a greater diversification of crops in irrigated areas as compared to the almost complete concentration on food crops in unirrigated areas. Which of the more remunerative cash crops will be chosen seems to depend upon many factors which can be isolated only by more detailed studies of agricultural location. No single factor, such as climatic or soil conditions, proximity to markets or processing facilities, or traditional skills in the area, is probably sufficient to account for the actual selection of the cash crop. However, once an area has concentrated on a particular crop and the people of the area have acquired the necessary skills, techniques, and

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10. T. S. Trent, "The Nature and Significance of Socio-Economic Studies", Mysore Sakkare, October 1955.

11. Studies in Economics of Farm Management in Punjab, Report for the Year 1954-1955. The Directorate of Economics and Statistics, Ministry of Food and Agriculture, Delhi, 1957, p. 135.

equipment needed for the cultivation and processing of the crop, there seems to be a tendency for everybody to fall in line with this pattern. The area tends to become a sugar cane area or a paddy producing region or a paddy and wheat producing region, as the case may be. The establishment of a sugar factory or a cotton mill may exert a powerful influence on the crop pattern of the entire surrounding area.

As a matter of fact, whereas the changing and uncertain seasonal conditions prior to irrigation usually call for a certain variety of crops, the availability of water may make it profitable to abandon diversification in favor of one or the other monoculture. Thus, sugar plantations often do not consider it worthwhile to grow anything but sugar cane. Sugar factories likewise favor the specialization on sugar cane by the cultivators in the adjacent areas. In the Mettur-Tanjore area, which is particularly well suited for the cultivation of paddy, the area under paddy has gone up from 38.3 % of the total cultivated area in 1931 to 80.8% in 1851; all other crops show declines, while some of the crops such as spices, vegetables, fruits, industrial and miscellaneous crops have almost completely disappeared.[12] Nor have there been any attempts to experiment with other commercial or industrial crops such as cotton.

B. From Subsistence Farming to Cash Crops

The concentration on higher valued crops sets in motion what is probably the most significant long-run socio-economic influence of river valley projects on the structure of agriculture: the gradual elimination of subsistence farming and its integration into a wider regional and national market. The final outcome of this process is a monetization of exchanges and a commercialization of agriculture which makes the latter dependent upon urban markets and urban supplies of finished products.

The extent of this monetization and commercialization can be demonstrated in a variety of ways. For example, the proportion of income received in the form of money and the expenses met by monetary payments tend to increase in wet farming areas as compared to dry areas. Twenty years after the introduction of irrigation in the Godavari and Pravara canal area (Bombay State), it was found that the disposal of important crops differed radically on irrigated farms from that of unirrigated farms. Whereas irrigated farms sold 70% of their total crop (measured in value) in 1938/39, the corresponding percentage for totally dry farms was 34.5%. The difference is even more striking if expressed in terms of absolute monetary figures. Whereas the total annual receipts of the average dry farmer for produce sold were only about Rs. 200, farmers belonging to the irrigated areas showed a total money receipt of Rs. 1,500 (with Rs. 3,000 in the most intensively cultivated irrigated areas).[13]

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12. S. Krishnamurthi, Pilot Survey of the Influences of the Mettur Irrigation and Hydro-Electric Project on Agriculture and Agro-Industries in Pattukkottai Taluk of the Tanjore District Madras State, Planning Commission Research Programmes Committee, New Delhi, 1948, mimeographed.

13. D. R. Gadgil, Economic Effects of Irrigation, Poona, 1948, p. 74.

This relative increase of the importance of cash sales has the further effect of replacing, at least in part, payments formerly made in kind (e.g., rent, farm labor, village artisans, and village functionaries) by monetary payments. The irrigated areas show a significantly smaller percentage of payments made in kind to total farm expenses than do the dry areas. It is true, with greater need for farm labor, artisans' and servants' total payments in kind on irrigated farms exceed those made on unirrigated farms. Outlays for other purposes do not seem to show the same uniform trend towards monetization. While the requirements for fertilizer and manure are met by cash purchases by the irrigators (as against an almost complete dependence of the dry farmers upon their own inadequate supplies), the requirements for fodder, seeds and plants are met to a very large extent from their own produce. It is difficult to say whether this means that the transition towards a cash economy has reached some kind of equilibrium short of complete specialization, or whether the survey merely caught a particular point in a continuous process. Even so it remains true that the old system of subsistence farming is replaced by an exchange economy in which payments are received and made increasingly in money. This monetization of farm transactions has the effect of establishing a substantial measure of integration between the region and the rest of the national economy.

Closer integration with the rest of the economy is usually mediated by various middlemen and marketing agencies who will claim a share of the total profits for their services. That is to say, in addition to the traditional money lender, the cultivator is now faced with a group of persons upon whose services he becomes dependent and whose interests do not necessarily coincide with his own. Moreover, there develops a new kind of dependence upon outlets and prices. A drop in the price of sugar may hit the irrigated village economy in essentially the same way as a bad harvest--with this difference: that the latter is perhaps more easily understood than the former.

Another effect of the monetization of farm transactions is the decline of the demand for the services of village artisans such as carpenters, smiths, potters, barbers, and dholis (laundrymen). This seems to be a regular pattern. An increase in purchasing power and easier contact with towns and cities (made possible by improved means of transportation) tends to give rise to a demand for city products and services (plows, pots, pans, barber services, textiles, not to speak of bicycles and flashlights), even though the village products may be perfectly adequate and aesthetically perhaps more satisfying and less standardized. Village studies in India confirm this tendency of villagers to turn away from indigenous artisan products as soon as additional purchasing power combined with contact with urban centers make such a shift possible.

C. The Stabilization of Farm Output

Inadequacy and unevenness of rainfall in unirrigated areas make Indian agriculture a particularly uncertain and risky business, the degree of which can be measured by the extent of crop failures. If the average rainfall during the growing period is inadequate or unevenly distributed, the entire crop or a high percentage of it may never mature and the area suffers famine. Crop failures of this kind can be measured by the percentage of matured crop to total area of cropping. The lower the percentage the greater the extent of crop failure.

In some areas of India the amount and distribution of rainfall are such that agriculture has been aptly described as a "gamble in rains". Whenever the total amount of rainfall or its distribution fails to live up to the requirements of plant growth, crop failures occur to a lesser or larger extent. In the Hissar District (Punjab), where until recently irrigation had not made much headway and where the nature of the soil would not permit the land to bear more than one crop even in years of normal rainfall, available data covering 15 years (1939-1954) indicate that in three years more than two-thirds of the crops failed to mature; in 7 yeasr failures ranged between 41.9% and 71%; and only in one year did 88.2% of the crop mature.[14]

In the area in which the 1952-53 study of the potential effects of the Bhakra Dam was conducted, a large part of the crop was lost due to inadequate rainfall. As much as 85.25% of the bajra crop did not mature. Conditions of other crops were only slightly better: 50.58% of jowar (Sorghum), 100% of watermelons, 46.7% of Gowar (Cyamopsis tetragonaloba); and 12.31% of Mint had failed during the year under report. Many other crops had been complete failures and gram (Cicer arietinum), barley, and wheat suffered losses of 86.3% and 85.3%.[15]

The social losses of crop failures can be measured either in terms of the value of the crop lost or in terms of the waste of seeds, family and hired labor (wages), and bullock power or the loss of public revenues due to the suspension of the collection of land taxes and the remission of installments of various government loans and substantial expenditures for relief measures to drought areas.[16]

By providing an assured supply of water over the entire growing season, irrigation changes the nature of agriculture. Instead of a gamble in rains, farming becomes an activity with a more or less predictable outcome. As compared to the extreme variations in the percentage of crops matured that was characteristic under former conditions, farm output tends to be stabilized by irrigation. The extent of the stabilization can be measured either directly in terms of the percentage of total area under fully matured crops or indirectly in terms of the increased output over a representative period of time long enough to include years of drought and inadequate rainfall. By reducing the risks of uneven rainfall, irrigation makes the supply of foodstuffs and farm output less dependent

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14. R. L. Anand, Punjab Agriculture, Facts and Figures. Government of the Punjab, Economic and Statistical Organization, Publication II, Changigarh, 1957, p. 5.

15. Gurdit Singh and Swarn Singh, Effects of Bhakra Dam Irrigation on the Economy of the Barani Villages in Hissar District, 1952-53, Economic and Statistical Organisation, Government of Punjab, Publication No. 32, Chandigarh, n.d., p. 13.

16. While no overall statistics seem to be available on these financial losses to the state, a careful reading of the Indian Press supports the conclusion that these losses are not only substantial but a regular phenomenon in most drought areas.

upon the vagaries of the weather and thereby places the whole planning effort including the long-run industrialization plan upon a sounder foundation.

This conclusion finds dramatic support by a comparison of the extent of crop failures in Hissar District in the Punjab, which has a relatively low percentage of total area under irrigation, with extent of crop failures in the Amritsar District, where 90% of the crops are irrigated. During the last 15 years the percentage of crop failures in the Amritsar district never exceeded 7/3% (against a maximum of 71.0% in the Hissar District) and for the most part was 3.8% or lower.[17]

D. The Intensification of Farm Production

In order to obtain the fullest possible benefits of irrigation, it is necessary to make more intensive use of human labor, bullock power, fertilizers and manure, and improved seeds as well as farm equipment. More manpower is required for such purposes as clearance, levelling, planting, harvesting, and supervision; draft animals are worked for a longer period during the year and hence consume more fodder and must be fed intensively over a longer period of time. Irrigation crops such as sugar cane and rice require the use of more fertilizers and manure, and these in turn produce the best results only if they are applied in proper proportion with more water and improved varieties of seeds. In short, irrigation calls for a more intensive form of agriculture than dry farming under conditions of normal rainfall. The new pattern of agriculture is reflected in a new pattern of farm inputs and farm expenditure. A study of these patterns of farm expenditures is of considerable importance for an understanding of the economic impact of irrigation, inasmuch as it indicates with some precision the new input requirements called for by the new method of farming. In fact, reliable comparative data on farm expenditures in dry and irrigated areas might enable the Planning Authorities to estimate the new requirements of manpower, of bullocks, of fertilizers, improved seeds and other farm inputs called for by the irrigation component of river valley projects.

An inquiry into the monthly distribution of manual and bullock labor in a dry farm area (Hissar District, Punjab) for 1952-53 shows that the workdays of manual labor for farm cultivation are concentrated lragely during the five months from July to November when sowing and harvesting operations are conducted. Hired labor as well as bullock labor follow almost the same course. There is practically complete idleness of manual and bullock labor during the months of December, January, and February.[18] On dry farms the average

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17. Anand, op. cit., p. 24. Needless to add, a low percentage of crop failures does not mean absence of fluctuations in real output or variations of monetary yields due to changes of crop prices, which in a cash economy determine the relative success or failure of the farm enterprice. Hence, low percentages of crop failures are not equivalent to stability of farm earnings, particularly if the cash crops have a higher yield variability and are subject to greater price fluctuatoin than the crops grown before irrigation was introduced.

18. Singh and Singh, op. cit., p. 28.

number of days worked per year is not more than 153.9, or, expressed in different terms, the average number of hours worked per day is 3.37 hours.[19] By extending the period of cultivation and by making it less dependent upon seasonal rainfall, irrigation has the effect of spreading work more evenly over the entire year.

Moreover, irrigated crops call for a much more continuous and intensive use of manual labor and bullock power. In the two districts which were the subject of a special cost accounting and survey sample in the Punjab in 1954-55, it was found that while the use of human labor un unirrigated crops per acre was 12 adult man days[20] per year, the employment of human labor on irrigated land was about 24 man days. Similarly, the use of bullock power showed a substantial increase on irrigated cropped areas as compared with dry areas (18.7 against 11.6 days of 8 hours). Whereas about 90 percent of the total man days on unirrigated cropped areas are contributed by family and exchanged labor, only 82 percent are provided in this fashion on irrigated land. That is to say, the percentage of hired labor[21] increases from 10 to 18 percent. Whereas unirrigated areas make use of hired labor only to the extent of 1.3 man days per acre, the irrigated areas used 4.1 man days or more than three times as much hired labor.[22]

In this connection Gadgil's earlier study of expenditure data is still of interest. While total outlays for paid (casual and contract) labor in the Godvari area (expressed as a percentage of total farm expenditure) were only slightly higher on irrigated farms (5.7% as against 5% on unirrigated farms), the irrigated farms showed a much lower percentage of hired labor paid in kind than did the unirrigated farms.[23]

Our own inquiries and information obtained in several areas affected by irrigation schemes (Mandya in Mysore, Chalakudy in Kerala, Erode in Madras) support the thesis that a perennial supply of water makes for more as well as

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19. Ibid., p. 29. These figures which apply to a specific district in the Punjab are merely an illustration of the general problem of underemployment in India. For the country as a whole, recent estimates indicate that 30 million people are engaged in gainful work for five days a month; 40 million for less than 10 days a month and about 53 million for less than 15 days a month. Economic Weekly, January 17, 1959, p. 71.

20. An adult man day is equivalent to 8 hours per day.

21. Hired labor includes besides farm servants engaged for long periods on farms, also all types of casual labor of men, women, and children engaged in rush periods for harvesting, sowing, or bringing in of crops, or picking of cotton or vegetables.

22. All data cited in this paragraph are from Studies in Economics of Farm Management in Punjab, op. cit., pp. 73-79, Tables 4.25, 4.26, 4.28, and 4.25. For definition of units of measurement see Para. 4.26.

23. Gadgil, op. cit., p. 49.

more continuous employment. In some of the irrigated areas of Southern India, it has become an established practice to import migrant labor from adjacent non-irrigated farming areas during the planting, weeding, harvesting, and threshing phases of rice cultivation when a maximum effort is required to handle the crop.

While there is still unemployment and underemployment in irrigated areas, this must not detract from what might be called the employment effect of irrigated farming in India. The impact of river valley projects on employment during the construction period has probably been exaggerated if we consider the need for capital intensive work processes called for by the building of dams and reservoirs; however, the contribution which the irrigation component could make to the absorption of the unemployed and underemployed in rural India after the completion of these projects has not been sufficiently stressed. This effect on rural employment which results from the greater intensity of farming made possible by irrigation must have a more lasting and significant effect on employment than the construction of the dam. Bullocks are used for a longer period of time during the year; as a result there is a higher demand for fodder crops to sustain the more intensive use of draft animals. In addition to human labor and the use of animals, there are other important expenditures which figure prominently in the expenditure account, and are significantly higher on irrigated as compared with unirrigated areas. A detailed break-up of these expenditures is shown in Table 2.

Table 2. Break-Up of Expenditures for Different Farm Inputs for Crop Production per Acre on Irrigated and Unirrigated Land, 1954-55, in Rupees[24]

	Irrigated	Unirrigated
a. Human labor		
Family and exchanged	34	16
Hired	11	3
	45	19
b. Bullock labor	37	19
c. Seed	9	6
d. Farm yard manure	5	-
e. Fertilizer	2	-
f. Interest on fixed capital	3	2
g. Depreciation on implements	6	3
h. Artisans	2	2
i. Rent and rental values of land	58	26
j. Land revenue	2	2
k. Irrigation charges	9	-
l. Miscellaneous	-	-
Total value of inputs per irrigated acre held	178	79

24. Studies in Economics of Farm Management in Punjab, 1954-55, op. cit., pp. 73-74.

The higher input of human labor and bullock labor is clearly reflected in the higher expenditures for items a and b. Whereas there are assignable input values for manure and fertilizer on irrigated areas, there are apparently no such input items on unirrigated farms--a clear indication of the greater intensity of cultivation under condition of irrigation. Also it is interesting to note that rent and rental value of land increases in proportion to total outlays; in both cases, this item amounts to roughly 33% of total outlays. That is to say, while the absolute amounts paid to landowners are increasing from Rs. 26 to 58, the relative share (as a percentage of total farm expenditures) received by the owner does not seem to be affected in one way or another by the intensification of farming called for by irrigation. Since the landlord is usually not a partner, even in a small way, in irrigated farming and does not make payments for land improvements, his increased rental income is for all practical purposes "unearned" and hence should be available for land taxes and water rates.

Irrigated land also shows a higher intensity of cropping as compared to unirrigated areas. There are unirrigated areas in India in which there would be considerable scope for an extension of the cultivable area by reclaiming uncultivated but cultivable waste land. Gadgil's data revealed a considerably lower percentage of "current fallow" and "uncultivated waste" on irrigated as compared to unirrigated farms (4.5% versus 11.7% current fallow and 0.8% to 2.1% waste). The percentage of total uncultivated area was 13.7% on irrigated farms as against 15.7% on unirrigated farms.[25] In the area of the Mettur-Tanjore project (Battukkottaitaluk) the percentage of cultivated area has shown a steady increase between 1931 and 1951. It now amounts to 46.8%, against only 26.1% in the non-project area. While the area brought under new cultivation has increased by 43.9%, there is evidence that the area should be further increased if the available water were used more economically by the farmers in the project area.[26]

It would be wrong to believe that the data presented in this section represent a measure and an approximation of the potential intensification of farming which irrigation is likely to render possible in India. This is made particularly clear by Krishnamurthi's study which leaves no doubt that the intensification of farming is still far from what would be called for by modern methods of agriculture.[27] If Krishnamurthi's findings are indicative of conditions in other areas

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25. Gadgil, op. cit., p. 27.

26. Krishnamurthi, op. cit., pp. 71-72.

27. Very few improvements in cultivation practices have been introduced in the area of the Mettur-Tanjore Project. For instance, the practice of green manuring has not been introduced. Only 1.2% of the total paddy is of the improved strain. There was only one instance of the Japanese method of rice cultivation. Only 8% of the total area under paddy in Battukkottaitaluk received an effective dose of ammonium sulphate in 1954-1955 when the campaign for the use of ammonium sulphate was at its peak. The proper application of green manure and ammonium sulphate alone would lead to substantial increases in yields.

affected by irrigation projects it stands to reason that there must be a wide gap between the actual and the potential benefits obtainable from irrigation in India.

E. Increased Productivity

Any assessment of the impact of irrigation on yields and output is complicated by the fact that water is only one factor among many that determine yield and output. Of the other factors only the following may be mentioned: the use of manure and fertilizer, the utilization of improved varieties of seeds, especially seeds that yield crops in a shorter growing period, crop rotation, proper planting, and adequate cultivating. Maximum results are obtainable only by a combination and proper proportioning of the various factors. Furthermore, there are special statistical problems and conditions which make it hazardous to generalize from official yield data in India that are calculated by dividing total output by total acreage. First, there is the possibility of systematic underestimation of output due to the cultivator's interest in not disclosing the full magnitude of his harvest. This applies particularly to wartime data when compulsory collections were either practiced or feared. Second, any shift to the more highly priced cash crops has the effect that less valuable crops are grown increasingly on the less advantageous soil. And third, India has been forced to expand the area of cultivation on marginal land yields very poorly in the absence of improved methods of cultivation. For all these reasons yield data derived by dividing total production by total acreage convey the picture of India as a country where soil fertility has been stabilized at an exceedingly low level.[28]

In the light of the foregoing considerations it must be evident that comparative yield data on irrigated and non-irrigated tracts cannot be accepted for the time being as reliable measures of either the actual or the potential benefits of irrigation in India. The total potential effects of irrigation on yields and output can be ascertained only under controlled conditions where it is possible to experiment with modern techniques and methods in accordance with our contemporary knowledge of agronomy. Sugar cane, paddy, wheat, and jowar grown in experimental farms in India show average yields that exceed by more

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28. It is interesting to note however, that yield data derived from actual crop cutting surveys in specific areas and States show a more favorable situation. While they still show considerable variations of yields, reflecting mostly variations in rainfall, and while yields are still low, there is nevertheless some indication of a rising trend. The method of ascertaining yields by crop cutting surveys has been introduced as an experimental measure and will be utilized for framing official estimates of yields for each crop and each State only after it has been more firmly established. This information and preliminary tables showing yields for different crops based upon crop cutting surveys were made available to me by Dr. R. S. Sen, Economic and Statistical Adviser, Ministry of Food and Agriculture, Government of India. I also wish to acknowledge a discussion of this subject with Dr. Panse, Indian Council of Agricultural Research, Statistical Wing, Government of India.

than one hundred percent the yields obtained by farmers in adjoining areas. While it may be unrealistic to use yield data on experimental farms as the basis for calculations of the potential benefits of irrigation, it is certainly not more realistic to appraise the benefits of irrigation simply in the light of yield data which do not reflect the level of output which modern agricultural knowledge and techniques could open up to the Indian farmer. This is not to deny that the "soundness" of a loan advanced for the construction of an irrigation project depends upon actual rather than potential yields and output which modern technology has placed within reasonable reach. What is questioned, however, by the foregoing observations is whether the bankers' test of the soundness of the loan measured in terms of present yields and output is an adequate test of the socio-economic justification of the project. If India were to confine herself to the construction of river valley projects that are financially sound in terms of present backward practices and yields she may never be able to create the preconditions for an agricultural system that is capable of providing the necessary supplies of food and farm commodities for her urban communities and export requirements.

Yields on irrigated and unirrigated tracts--Available data on differences of yields on irrigated and unirrigated tracts show differentials of more than 100% for specific crops. For wheat, the most recent data from the Punjab indicate that whereas unirrigated tracts do not produce more than 4.3 to 7.7 maunds per acre, irrigated areas have yields of from 12.9 to 13.5 maunds per acre.[29] Pre-Independence estimates of average yield differentials on dry and irrigated lands vary from area to area. They range from 572 lbs. per dry acre to 967 lbs. per irrigated acre in the Punjab, and from 510 lbs. per dry acre to 1,250 lbs. per irrigated acre in Bombay state.[30] For rice the Punjab shows the greater variation (587 lbs. as against 1,269 lbs.), whereas the estimates for Madras State show yield differentials per acre of 1,138 to 1,694 lbs. In the more recent pilot survey conducted in the Tanjore District, it was found that the provision of irrigation through the Mettur Project "has by itself almost doubled the yield of paddy (rice in the husk), the average yield being 39 kalams per acre in the canal fed area and 20 kalams in the non-project area".[31] Even more significant differentials of average yields on dry and irrigated lands are reported for such important crops as jowar, ragi (a millet), gram, and barley in the Deccan.[32]

It is not necessary to comment in detail on these increases of average yields and output made possible by irrigation. Suffice it to emphasize merely that unquestionably irrigation is the strategic factor without which these in-

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29. Studies in Economics of Farm Management, op. cit., pp. 85, 95.

30. W. Burns, Technological Possibilities of Agricultural Development in India, Lahore, 1944, p. 56.

31. Krishnamurthi, op. cit., p. 73.

32. M. L. Champhekar, A Note on the Assessment of the Direct and Indirect Effects of Irrigation, Bombay, 1950, p. 26.

creases in yields and output would not have occurred. This is not to say that the increase in the supply of water is the only factor responsible for the improvements of farm yields and output. Certainly there were improvements in techniques of farming, such as the use of fertilizers, manures, improved seeds, new methods of planting and cultivation, which contributed to the final outcome; and it is important to realize that these improvements in techniques represent additional farm investments called for by irrigation farming. In this sense, the increased yields and outputs are not the net result of investments in irrigation but are the combined result of the joint investments in irrigation and improved techniques of farming.

The second point to be emphasized is related to the fact that actual increases in average yields and output in a particular region do not necessarily represent the limits of agricultural improvements. On the contrary, in view of the fact that in many areas under irrigation the utilization of water is still far from complete, and that improved techniques of agriculture are still the exception rather than the rule,[33] it is safe to conclude that actual yield improvements represent merely a fraction of the potential benefits obtainable from irrigation. In this connection, it is of interest to note that the reported extraordinary rapid increases of 60 to 90 percent in one year in the harvest for a continent the size of China are attributed (by Professor Rene Dumont, United Nations Technical Expert in India) to irrigation as the decisive factor and the use of natural and organic manures rather than chemical fertilizers as the secondary contributing factor.[34] The fact remains that India has so far not been able to make any rapid progress in agricultural output even when and where additional water was available for irrigation.

F. Effects of Irrigation on the Size of Holdings and Number of Farm Units

What is the effect of irrigation upon the structure of land ownership and tenancy? What is likely to happen to the average size of holdings and to the number of farm units? It is difficult to formulate unequivocal answers to these important questions. As far as the relative size of holdings is concerned, the available statistical evidence seems to support the conclusion that the average size of farms is likely to increase, and correspondingly, the number of farm units to decline. In other words, irrigated farming may ultimately lead to a consolidation of holdings. Gadgil's investigation, which was undertaken more than 20 years after irrigation was first introduced in the Pravara and Godavari irrigation project, showed that the average size of the 193 irrigated farms was nearly 40 acres and above the average of 33 acres in the control group of the 198 dry farms. But these findings may simply reflect the fact that the smaller units found it more difficult initially to convert to irrigation farming. Probably this is the reason why Gadgil merely advanced the negative thesis that the number of farm units do not seem to increase with irrigation.[35]

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33. See Krishnamurthi, op. cit., pp. 75-77.

34. The Economic Weekly, Bombay, January 17, 1959, pp. 60-61.

35. Gadgil, op. cit., p. 115.

A general tendency of the average size of irrigated farms to increase (and the number of farms to decline) could be inferred from data showing the relative profits and losses per irrigated acre held, classified according to size groups. The limitations of such calculations stem from the familiar necessity of imputing costs to the smaller size groups which work more with non-contractual family labor and less with contractually hired labor. To charge the smaller sized farm with the opportunity wages available on adjoining tracts--which may be correct statistical procedure--may have the effect of overstating their input costs. At the same time the proportion of total output devoted to the meeting of the minimum requirements for family needs and fodder for livestock is greater on smaller farms than on the larger farms, which once more makes it necessary to impute output values and opens the way to overstating the losses on the former. Nevertheless, the fact remains that the larger the size of the farm the greater the proportion of land devoted to the more remunerative cash crops (such as cotton, wheat, sugar cane, rice), and this must account for their greater profitability. Detailed cost accounting samples showing profits and losses per irrigated acre of land classified by size groups in the Punjab support the conclusion that returns per acre exceed costs per acre only for farms of 50 acres or more, and that losses per irrigated acre held decline as the size of the farms increase.[36] If these data are representative of the relative cost and return situation for different holding size groups they would seem to point to the conclusion that in order to be profitable irrigated farming requires larger holdings and ultimately tends toward the consolidation of smaller holdings.

Experiences in Montana indicate that high irrigation costs on smaller size holdings may lead to bankruptcy and to a subsequent consolidation of holdings. The average size of irrigated farms in Montana increased from 125 acres in 1919 to 223 acres in 1935. The average size of farms owned increased from 82 acrez in 1919 to 157 acres in 1934.[37] These data would lend support to those

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36. The following table summarizes the results of a cost accounting sample survey of the Amritsar and Ferozepur Districts in the Punjab (quoted from Studies in Farm Management in the Punjab 1954-1955, op. cit., p. 63):

Table 3. Input, Output and Profit and Loss per Irrigated Acre held, by Size Group, 1954-1955

Holding Size Groups (Acres)	Input Rs.	Output Rs.	Profit or Loss Rs.
0- 5	228	173	-55
5-10	208	184	-24
10-20	184	181	- 3
20-50	178	176	- 2
50 and above	141	147	+ 6

37. P. L. Slagsvold, An Analysis of Agriculture on the Valier Irrigation Project, Montana State College Bulletin No. 330, Bozeman, Montana, December 1936, p. 25.

who argue in favor of larger farm holdings in order to stabilize farm practices at a higher level of productivity and efficiency. The social effects of a trend toward larger holdings in India would be an increase in the number of landless workers who would have to seek employment either on the larger farms or in urban industries. In short, as in the case of other investments, the ultimate benefits of the irrigation component of river valley projects may be distributed rather unevenly and may give rise to far-reaching social dislocations for great masses of cultivators and village inhabitants.

H. Other Direct Effects

There are other important direct effects of irrigation which are frequently overlooked in discussions of the overall effects of irrigation. Their full significance can be understood only in the light of the fact that there are areas in India where shortages of water are regular occurrences during the dry season. The water table in these regions may be as low as 300 feet below the ground. Shortages of water threaten people and animals alike. Indeed, without an adequate supply of water the raising of cattle may be out of the question. In some areas and years the situation may become so acute that whole villages and communities must resort to rationing the available water or must fetch water from sources several miles away. In Northern Rajasthan water is said to be so brakish that people go a distance of 40 to 50 miles (sic!) for getting drinking water.[38] Irrigation projects prevent calamaties of this sort by making available an assured supply of water for drinking and cattle farming throughout the year. By raising the ground water level even in the non-project area, they have the further effect of reducing the costs of well-digging and thereby make it possible to extend the area under cultivation in zones that are not directly in the area of the project. These benefits of irrigation are typically of the nature of social utilities which have the tendency of diffusing themselves among the people within a particular region. The fact that they are social utilities in this sense does not make them in any sense less real and less important than the benefits which can be appropriated individually.

Conclusion

Admittedly the foregoing account is an incomplete picture of the total repercussions of river valley projects in underdeveloped countries. As we indicated from the very outset, we were not concerned here with the indirect or secondary effects which the change in the structure of farm production and the transition to cash crops may have on the structure of production and distribution in the surrounding area. Nor have we paid attention to the socio-cultural impact which the shift to cash crops may have upon the social structure and the world outlook of the population affected by the project. The preceding account is incomplete also insofar as it does not deal with such social costs as water logging, increased soil salinity, and irrigation-induced malaria which may be caused by a perennial supply of water in formerly dry areas in tropical or semi-tropical regions.

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38. According to Mr. Karni Singh's statement in India's Parliament. See Hindustan Times, March 26, 1958.

While it is possible to indicate the general direction of the economic changes which a perennial supply of water might bring about in an area formerly dependent upon an inadqquate and uneven supply of rainfall, a complete and detailed ex ante forecast of the repercussions of a given project is not possible.

In the first place, there is the fact that each project and each region has its unique physical characteristics. Topography, soil conditions, water table, climate, stream flow, population density, and the amount of unutilized land are likely to differ from region to region. A densely populated area like the Punjab will show different effects as compared with the impact of irrigation in a sparsely populated area like the region around the newly planned Rajasthan Canal. Obviously these difficulties are not unsurmountable. Regional surveys of the physical characteristics of a given area with particular emphasis on their significance for the irrigation and production potential of the area can throw considerable light in these questions. This is precisely the objective of the engineering surveys which are usually carried out prior to the selection of alternative sites for river valley projects. In this connection, one could perhaps hope for a closer cooperation between engineers, agronomists, and soil experts--not to mention the malaria expert.

But even if we had all the relevant data on the physical potentialities of a given region, there would still be a second uncertainty: namely, the fact that the effects of an irrigation project, especially in an underdeveloped area, depend also upon the responses of the rural population to the opportunities offered by the new productive factor. Will farmers be willing and able to make the necessary subsidiary investments called for by the new technique of farming? How will different sections of society respond to the additional output and income? Will cultivators work more, or will they work less? Questions of this sort can be answered only by persons thoroughly familiar with the typical response pattern of the rural population in the different parts of India and the reasons why these responses have not always lived up to expectations. Sociologists, antrropologists, agricultural extension workers, and irrigation administrators may have to be called upon to fill this gap in our knowledge, in order to enable us to anticipate correctly the effects of a perennial supply of water. It goes without saying that knowledge of the response (or lack of response) to the new technique would enable the planning authorities to provide the administrative organization designed to secure the necessary adaptations and acceptance of the innovations (e.g., new inputs, tools, fertilizers, improved seeds, etc.).

This brings us to a third reason why the effects of the irrigation component of river valley projects are not simply a function of the available water and land resources. As the experience of India indicates, these effects depend also upon the economic and administrative policies pursued by the government authorities. A policy of relative laisser-faire will give rise to different results than a policy of deliberate planning and appropriate administrative measures that are called for by irrigated farming. There are strong reasons to believe that in addition to an ingrained inertia and the widespread inclination to gamble in rain, inadequate planning of the distributaries and the tendency of charging high water rates in an effort to recoup the initial outlays is a relatively short time have acted as obstacles to a speedy transition to irrigation farming. In other words, here again the effects of irrigation will depend upon variables

which cannot easily be anticipated. However, the practical implications are clear. The job of the planning and irrigation authority is not finished with the completion of the dam and the storage of water. In order to assure the speedy utilization of the new capital investment and through it the maximum economic advancement of the region, it is necessary for the planning authorities to see to it that the strategic processes described in this article get under way with a minimum of delay, with a view toward setting into motion a cumulative process of economic development in the region.

Fourth, the full effects of any component of a multipurpose project depend also upon the interaction of the effects of any single purpose with those of all the other components. For instance, the availability of electricity may make it possible to supply the region with supplementary lift irrigation by electrically driven pumps and may provide a convenient and flexible source of power for village (cottage) as well as urban industries engaged in the processing and transformation of the agricultural raw materials. In short, the overall effects of any truly multipurpose project depend upon the effective coordination of the several components of the project. Finally, it stands to reason that the stimulating impact of any project depends upon the magnitude of its expansionary effects, as compared with the stagnation effects which have kept the region in a backward stage in the past.

It will be argued that without a detailed and precise forecast of the effects of a given river valley project it is impossible to arrive at a rational judgment of the relative worthwhileness of alternative investment projects. Indeed the question may be raised whether heavy capital investments absorbed by river valley projects in underdeveloped areas may not yield higher returns if allocated to such alternative uses as the improvement of agricultural techniques, better farm management, farm credit, farm marketing, and the extension of domestic and foreign markets. If we had the unequivocal answers to questions of this sort, the process of economic planning and resource allocation could be considerably simplified. Unfortunately, we are still far from the point where answers to questions of this kind could be advanced with any degree of certainty. The difficulty is not only that the total effects of irrigation are not known, but that the effects of the alternative investments cannot be easily estimated, either, with the precision that would be desirable. There is no scarcity of investment outlets in a country like India, and it is doubtless important to consider these alternative outlets. But what are and how can we compare the actual effects of investments in improvement in agricultural technology and farm management in a country like India? There is doubtless great need for an improved farm credit system that could take the place of the present system of moneylending at heavy interest rates. But what are the political chances for such reforms, and how will they be received? What are the probable returns of investments in agricultural extension, farm marketing, and perhaps a policy of guaranteed prices for specific crops? The same uncertainty surrounds investments in rural education, improved communications, and an effective campaign in favor of birth control in villages. While it is relevant to keep in mind that there are many ways of increasing the supply of food, it would be a fallacy to believe that we possess the knowledge of the actual effects and benefits of alternative measures with any higher degree of precision and certainty than is the case with reference to the effects of river valley projects. In fact, many of these alternative investments

are of the nature of social returns and external economies which tend to diffuse themselves throughout society. Furthermore, in a country like India with an inadequate and uneven rainfall and a rapidly increasing population in virtually all rural areas, neither improvement of farm techniques and farm management, nor concentration of production in a few surplus areas with comparative advantages (in terms of farming costs), would remove the obstacles which recurrent food shortages place in the way of economic growth and development. For even improvements of farm techniques could not overcome the cultivators' dependence upon an assured supply of water; and the concentration and intensification of farm production in a few areas with comparative (farm) cost advantages would still leave the shortage areas unsupplied, because the available overtaxed transportation system would not be able to handle the additional traffic. That is to say, the problem of food shortages could find a solution only at heavy additional social expenditures for transportation, which are usually left out of account by the critics of those who advocate long-run investments in regionally distributed river valley projects with admittedly long gestation periods but also a high degree of stability as to their capacity to provide a dependable supply of water throughout the year or the growing season.

Finally, it must be remembered that irrigation is only one of several components of most multipurpose projects, and that such projects are usually part of a general development plan. To judge the irrigation component in isolation, i.e., in terms of benefit-cost ratios, instead of within the context of the specific and the general social goals pursued with each of the components, is arbitrary and self-defeating. This is not the place to go into a detailed discussion of the variety of purposes and social goals of river valley projects. Suffice it to say that the economist qua economist disposes of no knowledge which enables him to reject a priori any of the social goals usually pursued by river valley projects. To apply the yardstick of the market to these goals is merely to repeat what we already know, namely, that the market has the tendency to neglect the long-term social benefits and to concentrate production in a few areas to the exclusion of others. If these other areas are nevertheless densely populated (as they are in India), if coal deposits are concentrated in one or two regions, and if the transportation system and the development of other overhead capital equipment has long been neglected (as in India), the goal of regional development by providing an assured supply of water for irrigation and electricity for cottage as well as urban processing and manufacturing industries cannot be rejected as unreasonable. The criteria of judging the reasonableness and worthwhileness of such investments can be found only in terms of a comprehensive and informed theory of cumulative growth, which will have to be based upon the substantive knowledge of the actual, i.e., physical production relationship and outputs which can be set in motion by the new capital investment.