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QUESTIONABLE CONCEPTIONS AND SIMPLISTIC VIEWS ABOUT IRRIGATED AGRICULTURE OF INDIA

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The motivation in writing this paper is to clear some misconceptions about Indian irrigation. Hopefully, this may minimize the scope for misunderstanding of irrigation-related phenomena that sometimes appear baffling even to seasoned scholars from the mainstream of disciplines like economics, statistics and agricultural sciences. At the very outset, it must be admitted that because of the increasing specialisation within disciplines and the explosive expansion of frontiers of knowledge the misunderstandings are indeed inevitable, more so when the observations are made in passing. Yet, their recurrence or persistence in the official reports, evaluation studies, research seminars, memorial lectures, and works of scholars fresh from the universities calls for a concerted effort to expose the naivete behind these misconceptions.

It is not my purpose to catalogue here who has given expression to the misconceptions pertaining to Indian irrigation and when and where. Undertaking such a task in listing is neither feasible for me nor is it needed for achieving my objective, namely, clearing up the misconceptions with a view to minimizing the scope for misinterpretation by the writers (or speakers) and the resulting puzzlement of everyone, including the writers (speakers). If the task has to be performed, it is equally imperative to sift the whole literature, highlighting both (*a*) those scholars who were not only free from the misconceptions and the misinterpretations but also did endeavour to clear these misconceptions, and (*b*) those scholars who have erred. As this would make the paper both lengthy and not easily readable, the task can await for a while.[1]

The focus is on the role of irrigation in enhancing crop yields, intensity of cropping, and farm output stability, as also in altering the crop pattern in favour of commercial crops. The key to correct understanding of the role of irrigation is to remember always the distinction between wet and dry crop seasons of an agricultural year (July to June). Considerable space has been devoted here to the impact of irrigation on the intensity of cropping, as this is an area of not inconsiderable confusion in otherwise well-informed circles. The confusion is so latent that some investigators continue to waste energies in demonstrating that irrigation and intensity of cropping are positively related—this is to counter the view, vigorously propagated at a seminar on irrigation by some economists about a decade ago, that

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1. The ideas have emerged during the course of an on-going, major empirical study, namely, Impact of Irrigation on Farm Economy which has been under progress for over four years at the Institute of Economic Growth.

Indian data do not reveal any positive relationship between the two variables.

INTENSITY OF CROPPING

The role of irrigation in boosting land productivity in land-scarce economies is a subject of considerable research. One dimension of land productivity is the number of crops grown *in a sequence* on a unit of crop land in one full agricultural year—the other dimension of land productivity is one of crop yield which will be examined subsequently. For all the crop land of an economy, a good measure of this number of multiple cropping (as distinguished from mixed cropping) is obtained by working out the ratio of gross cropped area to net cropped area, both figures being published in the original sources of agricultural statistics. Not infrequently, this ratio is multiplied by one hundred to express it in per cent points.

The lowest possible magnitude of this ratio, conventionally called intensity of cropping,[2] is unity (100 in per cent terms). The upper bound is usually placed at three (or 300 in per cent terms) on the presumption that the soil-climatic conditions of India do permit the raising of three consecutive field crops within a single agricultural year (July-June) in most parts of the country provided the farmers do not suffer from resource constraints of water, human and animal labour, working capital, etc. Water is rated as the paramount binding constraint during two of the three crop seasons as the Indian monsoon precipitation suffices for maturing only one rainfed crop per year in very many parts of India. Therefore, irrigation becomes a pre-requisite for obtaining both the second and the third crop in a year.[3] It is this simplistic perception of the role of irrigation that has given rise to an expectation of one-to-one correspondence between incremental gross cropped area and expansion in irrigated acreage. That is, if an addition of 'x' hectares is reported in irrigation facility during a given time span, a naive expectation of 'x' hectares addition to gross cropped area is raised. It is most probably because of such a one-to-one correspondence that some scholars entertain or visualise the following variants of this corrspondence:

(1) Over time, the intensity of cropping ought to rise in full harmony with the rise in per cent irrigated area, that is, one point rise in per cent irrigated area (defined as $\frac{\text{irrigated area}}{\text{cropped area}} \times 100$) be accompanied by one point rise in the intensity of cropping expressed in per cent terms.

(2) Irrigation ought to give rise at least to the double cropping of farm land in a single year—one rainfed crop raised with monsoon precipitation and the other raised with the aid of irrigation.

2. Sometimes—especially in FAO documents—'intensity of cropping' phrase refers to the ratio of cultivated land to cultivable land in an economy.

3. Some farmers with unduly large farm holdings, apparently not suffering from an irrigation constraint in the dry season, are observed to have preference for leaving the fields fallow in the dry season.

I describe these as naive expectations about the role of irrigation in improving land productivity. To begin with, these rest on a tacit presumption that establishment of irrigation facility is motivated by the goal of obtaining two or three consecutive crops from land resource in one single agricultural year. If this were really so, irrigation facility would have been so established as to aid cropping in the two dry crop seasons during which rainfed farming is infeasible because of the water constraint. The history of irrigation in India does not lend support to such a proposition. This history is characterized by (*a*) an attempt to protect the main rainfed farming of one crop per year against the periodic drought, (*b*) to raise rural incomes by enhancing crop yield and by changing the crop pattern towards more remunerative crops that need more water than is available from natural precipitation, and (*c*) by extending cropping towards both culturable arid lands and the two dry seasons of the year.

Thus, the realisation of one-to-one correspondence between irrigation and intensity of cropping can occur under very particular situations such as (1) irrigation facility is created for the dry season only when rainfed farming also continues in a tract and (2)though irrigation is for the main crop season only, say for irrigated paddy during *kharif* season, yet it incidentally promotes the cultivation of an unirrigated pulse crop during the ensuing *rabi* season on the residual moisture of the heavily-irrigated paddy field. To the situation(1) must be added a close rider, namely, farmer beneficiaries of irrigation refrain from altering their crop pattern from crops of one season duration to crops of two or three season duration. This is an unrealistic proviso because farmers may find it more remunerative to grow such long duration crops (sugarcane, bananas, cotton, chillies, ginger, etc.) instead of two or three consecutive crops of one season duration once their access to water changes for the better. If this perception of farmer behaviour is correct, it is futile to expect one-to-one correspondence between irrigation and intensity of cropping even in the apparently favourable situation (1). Needless to add, entertaining such correspondence in other situations in which irrigation is promoted with the following objectives is no less unwarranted: (*i*) to insulate the main monsoon-based crops only against rainfall failure; (*ii*) to enhance the yield of the principal monsoon-based crops because irrigation facilitates input intensification, especially of chemical fertilizers and high-yielding varieties (HYV) seeds which are key inputs for obtaining high yields; (*iii*)to encourage the cultivation of foodgrains, especially finer cereals (paddy in place of millets, maize and jowar, and wheat in place of barley)that are primarily needed for public distribution system; and (*iv*) to encourage the cultivation of sugarcane and cotton for the rapidly expanding sugar and textile industries respectively.

Given the vast diversity of agro-climatic conditions, on the one hand and the great variety of irrigation means, on the other, it is totally unwarranted to visualise *a priori* any one uniform relationship or correspondence between irrigation availability and intensity of cropping for the country as a whole. There is thus need for separate norms of correspondence for each region or tract against which one can contrast the regionwise or tractwise observed correspondence between irrigation and the intensity of cropping. Of course, this is not an easy task to accomplish in practice. If at all some working norms are needed for appraising the empirically evaluated correspondences, I venture to suggest the following parametric scheme of things.

For most non-hilly tracts, a plausible working norm could be: one unit of irrigated area ought to generate 'f' units of increment in gross cropped acreage, where 'f' is a fraction that measures the seasonal composition of irrigation facilities, *i.e.*, to what extent irrigation facility is oriented towards the two dry seasons. If irrigation availability is expressed in relation to net cropped acreage, the correspondence norm may be envisaged as follows: increase of one percentage point in per cent irrigated area[4] gives rise to 'f' percentage points in the intensity of cropping.

For sub-montaine and mountainous regions, especially of the Himalayas, where climatic conditions favour production of a sequence of two crops even without the aid of irrigation, the impact of irrigation introduction on intensity of cropping can be nearer zero (it can become even negative if irrigation enables the farmers to switch from one-seasonal crops to two-seasonal and annual crops).

The question now is: what is the value of 'f', the parameter that indicates the orientation of irrigation towards the two dry seasons when rainfed farming is not feasible? Since irrigated area statistics in India are not published according to each of the three crop seasons, one has to ascertain them from cropwise data for irrigated crops which are distinguished according to season of the year. Our estimational efforts indicate the following order of 'f' values:

1.	North India (Uttar Pradesh, Punjab and Haryana ..	0.65
2.	East India (Bihar, West Bengal and Orissa).	0.35
3.	South India (Andhra Pradesh, Tamil Nadu and Karnataka)	0.24
4.	Western India	
	(*a*) Gujarat and Rajasthan	0.68
	(*b*) Maharashtra	0.3
5.	All-India	0.48

For North Indian plains, two-thirds of the irrigation facility is oriented towards *rabi* and summer season cropping. The same holds good for Gujarat and Rajasthan portion of Western India. As one moves towards East India (or towards Maharashtra in the West), the 'f' fraction diminishes to an order of magnitude equal to one-third. The lowest magnitude of the order of one-fourth is found in the South. Thus, the working norm for adjudging the impact of irrigation on crop area expansion may be placed around 0.66 for North India (where private tubewells play a major role in the irrigation system) and Western India (Rajasthan and Gujarat where both dugwells

4. Per cent irrigated area for the economy as a whole is usually measured in two ways, either relating 'net irrigated area' to 'net cropped area' or 'gross irrigated area' to 'gross cropped area'. In the present context, 'f' is better measured by relating 'gross irrigated area' to 'net cropped area'.

and tubewells are of major significance); 0.33 for East India and Maharashtra, and 0.25 for South India where tanks and canals predominate in the irrigation system. In other words, the expected increment in the intensity of cropping consequent upon one percentage point rise in irrigation availability (measured by the percentage of gross irrigated area to net cropped area) may be reckoned as follows:

		Percentage points
1.	North India and Western India (Rajasthan and Gujarat)	0.66
2.	East India and Maharashtra	0.33
3.	South India	0.25
4.	All-India	0.48

Thus, for the country as a whole it is fair to expect that one percentage point rise in irrigation availability may be accompanied by almost half a percentage point rise in the intensity of cropping. Hence there is no ground for being baffled or puzzled (and to unnecessarily bewilder the reader) when one discerns absence of one-to-one correspondence between irrigation factor and intensity of cropping because the probability of such an occurrence is very very low in the Indian conditions. The most probable chance for such an exact correspondence is in the case of tracts having private tubewells which are a perennial source of irrigation, whereas the lowest probability is in the case of tracts served by tanks which are designed for protective irrigation of the single main season crop in much of the Southern peninsula.

To no small extent, confusion and bafflement have arisen because of faulty analysis and interpretation of the basic data on irrigation and intensity of cropping. Some scholars have confounded both themselves and their audiences by their crass failure to distinguish between 'intensity of cropping' and 'intensity of irrigation'—the latter is derived by dividing gross irrigated area by net irrigated area (expressed usually in per cent terms). Whereas the intensity of irrigation is a measure of seasonal or perennial nature of an irrigation source—a value of 100 implies one-seasonal irrigation and a value of 300 implies three-seasonal or perennial irrigation—it has been wrongly viewed as a measure of intensity of cropping attained on irrigated lands by scores of analysts. Since availability of irrigation in India is far from perennial, the intensity of irrigation is nearer 100 than 300, thereby generating a misgiving that irrigation potential is grossly unutilized. This is undoubtedly an inappropriate way of looking at the problem of underutilization of irrigation potential in India. Anyway, what is noteworthy is that a value of 100 for intensity of irrigation can be compatible with a situation of double cropping, *i.e.*, a value of 200 for intensity of cropping. This happens when irrigation is wholly earmarked for one dry season, say *rabi* season, when rainfed *kharif* cropping continues as before.

Here, I would like to underline that it is not normally possible, either from published statistics or from survey data, to compute unambiguously the intensity of cropping on irrigated and unirrigated portions of a holding.[5] Those who have ventured to do so—with a view to assessing the differential in the intensity of cropping due to irrigation factor—have only concocted baffling results (the source of bafflement is two-fold: when the differential turns out to be negative, or nearer zero). The truth of the matter is that a neat partition of a holding between irrigated and rainfed segments is often not feasible. For, how does one deal with those parcels of a holding on which rainfed crop is raised in one season and an irrigated crop in the other season of the same agricultural year? Results can change radically with the procedures adopted by scholars. Hence, this approach to sizing up the impact of irrigation on the intensity of cropping (namely, estimating the intensity of cropping for irrigated and unirrigated lands separately)should be avoided.[6]

Finally, I would like to comment on another approach, namely, comparing the intensity of cropping of more irrigated States or tracts with much less irrigated States or tracts. This comparative approach can produce misleading conclusions because the difference in the intensity of cropping level between the two selected States/tracts need not be wholly related to their difference in irrigation level. For, the difference in the intensity of cropping can arise from factors other than irrigation difference between the two States/tracts. In practice, it is very difficult to choose two States/ tracts which are alike in every respect other than irrigation facility. In the particular Indian situation, rainfall and irrigation are inversely related, that is, irrigation development is more in low rainfall tracts and less in high rainfall[7] tracts. Since both irrigation and rainfall positively impinge on the intensity of cropping (afterall, irrigation is a substitute for rainfall), the comparative approach would yield under-assessment of the impact of irrigation on the intensity of cropping.

One way around this problem is to use multiple regression equation method, whence the number of States/tracts is sufficiently enlarged so as to obtain sufficient 'degrees of freedom' in analysis. Those scholars who have used this method of analysis have admirably succeeded in countering the claims of those who earlier questioned the very beneficial role of irrigation

5. Sawant, while reacting to Dr. Panse Memorial Lecture by V.K.R.V. Rao (who first questioned the existence of any beneficial impact of irrigation on intensity of cropping and thus concluded that Indian irrigation source is grossly unutilized), was the first to point out this. See V.K.R.V. Rao, "New Challenges Before Indian Agriculture", Dr. Panse Memorial Lecture, April 26, 1974, First Annual Conference of the Agricultural Research Statisticians and 27th Annual Conference of the Indian Society of Agricultural Statistics, New Delhi; S. D. Sawant, "Extent of Multiple Cropping in Irrigated and Unirrigated Areas of India: Some Implications for Usefulness of Irrigation Statistics", *Indian Journal Agricultural Economics*, Vol. XXX, No. 2, April-June 1975. Dharm Narain and Roy also underlined it later in their study exploring the relationship between irrigation and intensity of cropping. See Dharm Narain and Shyamal Roy: Impact of Irrigation and Labour Availability on Multiple Cropping: A Case Study of India, Research Report 20, International Food Policy Research Institute, Washington, D.C., U.S.A., November 1980.

6. The draft report of the 1976-77 Census of Indian Agriculture, recently circulated for comments only, suffers from this lapse. Professional ethics refrain me from citing bewildering results from this report.

7. While comparative analysis is an age-old tool of research and knowledge gathering, even seasoned scholars are prone to tripping in inferences when they happen to ignore this empirical inverse relation between normal rainfall and extent of irrigation development over space.

in raising the intensity of cropping in India. Yet, one has some reservation about this approach also. The source of this reservation is the cross-sectional data. As argued earlier, the magnitude of the beneficial impact of irrigation on the intensity of cropping varies widely from tract to tract. Unless the cross-section is restricted to similar tracts, one is violating the statistical requirement for regression analysis, namely, one definite magnitude of the regression coefficient of the irrigation variable. If the estimate of this coefficient turns out to be statistically significant in a nation-wide cross-section, it means no more than the positive role of irrigation in raising the intensity of cropping in all regions that comprise the cross-section. But the regression coefficient that emerges from this regression equation cannot be taken at its face value. As the interest of research is primarily in the very magnitude of this coefficient, one must statistically test it for its significance for being no different from some expected or hypothetical level 'f'. (The usual testing is against the trivial hypothesis of $f=0$)

YIELD IMPACT OF IRRIGATION

From the viewpoint of land productivity, the crop yield dimension is of equally great interest. Here, the scope for misconceptions about the role of irrigation is indeed minimal. For one reason, scholars have no simple norms to go by. This has, however, not prevented some of them from appraising the levels of crop yields under irrigated conditions in India, and concluding on a note of dissatisfaction or disenchantment with the role of irrigation in raising the crop yields. But this has not produced any noteworthy bewilderment of the reader. If Indian yields are far below the levels prevailing elsewhere in the world (or those attained on the tiny plots of the Indian farm research stations), the gap is not viewed with any alarm —instead it becomes a source of optimism for some who are critical of India being doomed by the population explosion. Thus, if Indian rice yield under irrigated condition is 1.8 tons/ha. as compared to 6 tons/ha. in the Far East countries, few serious readers would be tempted to attribute the yield gap to the inefficiencies of the Indian irrigation system alone. Afterall, irrigation water alone cannot push the rainfed rice yield (of the order of one ton/ha.) to the Japanese or Korean or Taiwanese level. Not to speak of the huge differential in fertilizer differential, the entire framework for farm production in the Far East is geared to achieving high crop yields.[8]

Those who have kept their sights low and compared irrigated yields with unirrigated yields in Indian conditions, have often found a positive yield impact of irrigation. But sometimes the yield impact turns out to be so marginal that it appears totally incommensurate with the cost of irrigation. It is in this context that both the analyst and the reader are left in a state of discomfiture: why does a farmer use irrigation when it does not appear

8. It is not simply a matter of provision for drainage along with irrigation facility (or flood control); a good framework also means a buoyant non-farm economy, efficient public administration, just law and order, etc.

to be a worthwhile proposition from his own private angle? When confronted with such situations, it is prudent to investigate two things. First, are the soil-climatic conditions comparable for the areas to which irrigated and unirrigated yields data pertain? Second, do these yields pertain to different crop seasons of the year? Afterall, to the extent rainfed yield pertains to superior soils, more favourable climate or crop season, the yield impact of irrigation factor is bound to be under-assessed in a simple scheme of differencing between irrigated and rainfed yields. To bring home the point at issue I am giving some examples which came to my attention from two scholars who were baffled by their results.

One scholar tried to seek support for his hypothesis that private irrigation has failed to develop rapidly in the East Gangetic plains because of poor returns to such investment. Towards this end, he computed the excess of irrigated over unirrigated yield of wheat crop for the Farm Management Study (FMS) district of Deoria (East Uttar Pradesh), netted it out for the associated input costs of irrigation and compared it with the reported cost of irrigation. The source of the disconcerting result turned out to be the soil-climate factor: while rainfed wheat was being exclusively grown by sample farmers located in the 'tarai' tract of the northern part of the district, irrigated wheat was reported from non-tarai tract in the southern part of the district. Since 'tarai' soils of the Indo-Gangetic alluvium are known for their high moisture (a kind of subterranean natural irrigation), these yield good crops without irrigation. Their subterranean access to moisture is so excellent at places that these soils have sustained the cultivation of sugarcane without recourse to irrigation even during the hot and dry summer months. To use wheat crop yield of such soils as a foil (control) for irrigated wheat yield grossly under-estimates the output-augmenting role of irrigation factor in Deoria.

The second instance that comes to my mind is about the role of irrigation in raising wheat yield in Ahmednagar district, another FMS district. Once again, the excess of irrigated over unirrigated wheat yield turned out to be incommensurate with the additional costs of irrigated agriculture. Here, the mystery was resolved by ascertaining from the FMS reports that the unirrigated wheat was raised exclusively on deep black soils which are known for their high moisture retentiveness. Though these are not suitable for double cropping, they yield good crops of wheat, jowar or gram during the post-rainy period if their moisture is not utilized for raising the main monsoon crop during the *kharif* (rainy) season. To the extent irrigated wheat is grown on non-deep black soils that can only sustain a rainy, and not post-rainy season crop, the comparative yield exercise unduly blunts the beneficial role of irrigation.

The climatic conditions of India permit the growing of the same crop in more than one season of the year. This is especially true of the tropical regions where extremes in climatic fluctuations are absent. In the same state or district one may come across the phenomenon of rainfed cultivation of paddy, groundnut, maize, bajra, *ragi*, jowar, *moong* (green gram), etc., in the main monsoon season (say *kharif*) and their cultivation under irrigated conditions in the rest of the two seasons, namely, *rabi* and summer (*zaid*) seasons. If rainfed and irrigated yields of a crop, that are being compared for assessing the yield effect of irrigation, pertain to such two different seasons in a region, it is not necessary that the irrigated yield must exceed the rainfed yield. Whether or not such a yield differential is observed is not germane to the question of output-augmenting role of irrigation. For that purpose, the whole of the irrigated yield should be deemed as output-augmentation of that crop.

IMPACT ON CROP PATTERN

One does not encounter any noteworthy misconceptions about the role of irrigation in altering the crop pattern. That crop pattern would become more market-oriented in the wake of irrigation is understandable because not all the additional output due to irrigation is likely to be absorbed in self-consumption. (Very small farmers alone may be able to so absorb the additional output.) Given the pressure for production for the market, it is questionable to presume that the cropping pattern would shift in favour of non-food or non-grain crops once irrigation is introduced. While irrigation is often a necessity for raising a few non-grain crops such as sugarcane and vegetables, many a non-grain crop from the family of oilseeds and fibre crops are raised in many parts of India without the aid of irrigation. Thus, it is not a very well-placed conception that irrigation encourages the production of non-foodgrains at the expense of foodgrains. In point of fact, the advent of HYV seeds for cereal crops has tilted the scales in favour of cereal crops to the extent irrigation is a must for the cultivation of these new varieties.

Many scholars have found that groundwater irrigation does shift the crop pattern in favour of non-foodgrains in the Deccan plateau and the Southern peninsular States of Tamil Nadu, Karnataka and Andhra Pradesh. But we should also take note of the fact that surface irrigation in these States induces lot of paddy cultivation. In fact, one often comes across exclusive preoccupation with paddy in the States of Tamil Nadu and Andhra Pradesh (where rainfed paddy is not a feasible proposition) once canal or tank irrigation comes. It is the field-to-field irrigation system of distributing water below the final outlet (or turn-out gate) that leaves no option for any farmer in the command to grow anything other than paddy, an aquatic plant ideally suited for continuous presence of water in the field throughout its growth period. If the farmers are given field channels that provide them individual access to the outlet point, a much more variegated crop pattern would emerge under surface irrigation works. In point of fact, it may altogether move away from paddy if canal or tank water is distributed in the same 'protective' manner as in the States of Punjab, Haryana and Uttar Pradesh

(Western areas) where paddy is little grown on canal water.[9] Thus, the system design and policy adopted for sharing limited waters in an egalitarian manner have great bearing on the final crop pattern that emerges in the wake of irrigation.

STABILITY ROLE

There is a widely-shared expectation that irrigated agriculture ought to be much less unstable than purely rainfed agriculture. Stabilisation is expected in terms of crop yield, total crop output and income stability. More specifically, it is viewed in terms of some insulation against the drought. But it is imperative to realise that drought is not the only cause of depression in yield/output/income. While yield and output may suffer from floods and cyclones, untimely rains and hailstorm, cold wave, pest attack, etc., that may bear no linkage with a drought, farm income can get depressed because of farm price getting depressed. Thus, no one need entertain the onset of an era of unfluctuating yield/output/income once rainfed farming is converted into irrigated one.

At the individual crop level, substitution of irrigation for rainfall deficiency ought to moderate the yield instability provided the advent of irrigation does not bring about other changes in the farm technology of this crop. This is a big rider, for irrigation does not leave the state-of-the-arts unaffected. It is known to promote the cultivation of newer varieties of the crop and greater use of chemical fertilizers. If the intrinsic capacity of the newer varieties for bearing moisture stress and resisting pest attacks is much less than that of the earlier varieties, one cannot be sure of a decline in yield instability despite the introduction of irrigation. The expectation of a beneficial impact of irrigation on yield instability at a crop level is valid if (*a*) the irrigation source itself is not vulnerable to drought and (*b*) the farmers adopt necessary pest and disease control measures recommended for the newer varieties. Of the two conditions, the reliability of the irrigation source during the period of water stress is of vital importance in curbing the yield instability.

Since output is a joint product of crop area and crop yield, output instability depends both on the instability of crop area as well as crop yield and on the 'covariance' of crop area and crop yield (*i.e.*, to what extent area and yield fluctuate in unison). Conditions for reduction in yield instability have been explored above. Normally, area instability should diminish in the wake of irrigation as planting decisions are now less influenced by the rainfall conditions at the sowing stage. However, if irrigation enables the cultivation of the same crop in one of the two dry seasons that follow the main monsoon season, area fluctuations can become serious if the irrigation availability for the dry season fluctuates positively with rainfall fluctuations. This bring us once again to the dependability of the irrigation source during

9. Here, private tubewells have promoted the rise of paddy cultivation as a favoured *kharif* crop. To some extent, the structure of tariff for pumpsets and its under-pricing adds to the farmer's incentive to go in for a heavily-irrigated crop like paddy instead of lightly-irrigated maize/bajra.

drought periods. Thus, decrease in crop output instability is vitally contingent on the dependability of the irrigation service during drought times.

As regards aggregate output of the farm sector, irrigation may render it less unstable if it is not dependable during bad rainfall years. This attribute of dependability is present in tubewells, deep dugwells and storage reservoirs of high 'dependability', and not in tanks, diversion canals and shallow dugwells. Thus irrigation *per se* cannot lower farm output instability.

Regarding stability of farm income, output stability is no guarantee of income stability. In the absence of price support and price stabilisation policy, one can hardly say *a priori* that incomes under irrigated farming would be necessarily more stable than under rainfed farming.

SUPERIORITY OF MINOR OVER MAJOR IRRIGATION

There is some sort of enchantment with minor irrigation, which is viewed to be superior to major irrigation works. A variant of this thesis is the superiority of groundwater over surface irrigation works. Superiority is a multi-facet attribute. As far as the questionable conceptions are concerned, the interest is confined to the following ones:

(1) Minor irrigation is less capital-using than major irrigation.
(2) Minor irrigation is more farm productivity raising than major irrigation.
(3) Minor irrigation does no environmental or ecological damage whereas major irrigation does.
(4) There are no public subsidies entailed in minor irrigation in contrast to heavy subsidies in major irrigation works.

What is important to keep in mind is that minor irrigation works comprise a variety of irrigation means: public and private tubewells (electric as well as diesel driven); traditional and modern wells equipped with a wide range of waterlifts; tanks, ponds, bundies, *kuhls*, etc. Though major irrigation works usually refer to canal irrigation, yet these need to be distinguished at least in respect of (*a*) the canal network being backed by a storage reservoir and (*b*) the protective nature of the water distribution policy. A canal system backed by an expensive storage reservoir is much different from one without it in terms of capital costs and farm production role. Likewise, a protective irrigation work differs from a productive work, especially in the matter of farm productivity level.

More often than not, conceptions about the superiority of minor over major irrigation works, especially in respect of capital costs and returns, are based on a comparative analysis of one type of minor irrigation work and one category of canal work, and the result hastily generalised for all minor and major works. This is patently unwarranted. More importantly, one must beware of the pitfalls in such comparisons. Let me illustrate this by the question of comparative capital costs.

One pitfall to avoid in capital cost comparison is not to take a partial view of the capital costs. The author has come across pro-minor irrigation protagonists either bemoaning the neglect of minor irrigation by underlining that the Five-Year Plan outlays for this purpose are very small in comparison to the corresponding outlays for the major irrigation schemes, or extolling minor irrigation works by pointing out that the Plan outlay per unit area of irrigation potential from minor works is far less than that for the major irrigation works. The pitfall here is the lack of realisation that the Plan outlays indicated for irrigation works in the Plan documents pertain to only the public sector schemes. Since (*a*) groundwater irrigation is a principal component of minor irrigation works and (*b*) the bulk of the groundwater development is within the private sector, the Plan outlays for the minor irrigation works in general and wells and tubewells in particular are partial outlays that are exclusive of the investment by the farmers from their own resources.

The protagonists of groundwater irrigation, who sometimes plead for groundwater development to the point of total exclusion of major irrigation dams altogether, must not forget two important facts. First, the principal water resource for irrigation in India as a whole is surface water, and not groundwater. More specifically, the ultimate groundwater potential, as per the present expert reckoning, is of the order of 40 million hectares of crop area, which is a little over one-third of the total (ultimate) irrigation potential of 113 million hectares, which when fully tapped, may just suffice for half the crop acreage of the nation. Given the relative greater scarcity of water than of the land resource, all sources of water need be tapped for sustaining a growing agriculture. Second, there is strong interdependence between groundwater and surface water. If surface water development occurs to the exclusion of groundwater, the environmental damage in the shape of waterlogging and soil salinisation are inevitable, especially in flat tracts where conventional horizontal drainage is ineffectual. Likewise, exclusive reliance on groundwater in low rainfall areas can deplete the groundwater table—this may damage groundwater resource if saline and brackish waters move into the voids created by excessive groundwater withdrawals. These untoward developments are best countered through conjunctive exploitation of both surface and groundwater. In point of fact, returns on investments in groundwater irrigation in low and medium rainfall tracts get boosted once the groundwater recharge improves from seepage of waters from canals and tanks. The surest way of inducing farmers to invest in groundwater irrigation in the Deccan plateau, where the uncertainty of groundwater availability inhibits groundwater development, is to strengthen the groundwater availability through extensive development of surface irrigation works which contribute to groundwater recharge in a substantial manner.

The virtues of tubewell irrigation have been extolled for the last two decades. Those who plead for this mode of irrigation must bear in mind its limitations and drawbacks. To begin with, tubewell technology is technically feasible for alluvial areas, and not for areas underlain by hard rock—as indeed is the case for much of the Indian land mass. Thus it is futile to urge the planners to introduce tubewell irrigation everywhere in the country. Secondly, it is not a harmless technology from the environmental angle. While it cannot give rise to waterlogging which is the bane of canal irrigation, it can prove disastrous in the long run in the semi-arid areas where saline waters coexist with sweet waters. Once the saline waters are pumped out inadvertently, these set in the process of soil salinisation.

It is true that surface irrigation in India is highly subsidised, the mounting losses of public irrigation works being a good indicator of this subsidy. Besides canals, minor works like public tubewells and tanks also suffer from the problem of losses on the revenue account. Whether these financial losses are inevitable (as believed by some irrigation administrators) is not the issue here. The point here is the existence of substantial subsidy in the working of minor irrigation works of both the public and the private sector. Besides capital subsidy in the construction of wells and tubewells by small farmers, one has to reckon with the huge subsidy in electricity used for operating electric pumpsets. The financial loss of the Electricity Boards on their rural electrification schemes is a good measure of this subsidy. However, starvation of urban-industrial areas of electric power by diverting it to rural pumpsets during times of weather crisis and at harvesting time is no small external diseconomy of the minor irrigation works based on the use of electric pumpsets.