Delivery of Canal Water in North India and West Pakistan

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The canal systems in North India and West Pakistan were set up by and large to prevent famine, at a time when it seemed more effective to spread the water thinly to provide each district a measure of famine insurance rather than to depend on transporting grain from surplus districts to deficit districts in this largely pre-railway age.

In the context of modern agriculture in which the time of delivery of water is as important as its amount, there are significant defects in the way in which the water is delivered under this system. The farmer cannot control water delivery to ensure its taking place when he needs it, nor can he predict water timing in a particular year so that he can choose his crops and the planting, fertilising and water schedules in such a way as to make the most of the water when he gets it.

One important way in which controllability of water might be achieved in some measure would be for farmers to sell water to one another or trade in it. Water trading and water sale are not now permissible. Yet these devices permit those closest to the growing of the crops to determine when water is of value to them and when it would be more advantageous to them to sell water or to advance or postpone its delivery as made possible by complementary needs on the part of others with whom water trading or sale is possible.

The idea of small-scale water sales and swaps within a given area may seem radical to those accustomed to a system which does not now include this feature, but a number of contrasting irrigation systems in various parts of the world include such practices.

One possible development to facilitate sale and trading of water might be some form of water-users' associations, comprising all farmers on a given outlet or watercourse, which could contract with the government for timed delivery of water and then manage internally the problem of allocation among ultimate recipients.

THE coming of the Green Revolution in India and West Pakistan has made clear that we must place more emphasis on the delivery of water to farmers, a subject on which our knowledge is scant. G A Narasimha Rao, the then chairman of the Indian Central Water and Power Commission, said in 1969, "I consider it the duty of the Irrigation Engineer to supply the required quantity of water at the right time on the farm". Although the words sound simple, they really are a large order for an irrigation system not designed with that goal in mind. In this paper we propose to discuss ways in which the objective might be met, and ways in which the present operation of the irrigation systems of North India and West Pakistan block its fulfilment. We limit our discussion to these areas, in which the system of canal irrigation on a large scale dates from the nineteenth century and in which it is regulated by the North India Canal and Drainage Act (Act VIII of 1873).

The pattern of development of the canal systems was set in the nineteenth century: even modern systems retain the characteristics imprinted by the British as they developed large-scale irrigation in Uttar Pradesh, Haryana, and Indian and Pakistani Punjab. The principal factor modifying the systems has been heavy private investment in tubewells within the last ten years on both sides of the India-Pakistan border. We will argue later in the paper that in part the introduction of tubewells on a large scale reflects the institutional inadequacies of the older system, especially in the context of new crop varieties offering high returns to sophisticated water management.[1]

An idealised picture of the distribution of water for irrigation in North India and West Pakistan would run something like this. Water is distributed to the lowest level of channels in the system, called watercourses, in such a way as to make water available to these watercourses in rough proportion to the culturable land commanded by each. Water is delivered to different parts of a canal system in a rotation sometimes called a Rotational Programme of Channels, because there is not enough water to run all parts of the system full at the same time except during the monsoon season and immediately afterwards. Each watercourse receives water from a canal of the system ranging in size from the small minors to large branches and may serve an area of up to about 1,200 acres, depending on the physical conditions. An area of this size usually includes the land of scores of farmers.

Deliveries of water to the farmers are arranged by the *warabandi*, agreed upon by the farmers concerned and fixed by the relevant canal official, which allocates a particular time of a particular day of the week to each plot of land. The farmer cultivating the land is then entitled to any water available in the watercourse during his weekly turn, say Sunday morning from midnight to three. If water is available in the watercourse at that time, he gets water. If there is no water, he gets none. The rotation of water among watercourses is supposed to be such that over the season, the amount of water made available in each will be roughly proportionate to the culturable land which it commands, and thus water deliveries to the farmer will be "fair", in the sense that each will get water in proportion to the irrigable land he holds.[2]

Although intended to be fair, the system's result is an unpredictable water supply. The unpredictability can be explained by remembering, first, that the system has little or no institutional

mechanism for local control of water deliveries. Second, that the rationing of water is not done through a market mechanism, but rather through a whole chain of institutional factors about which the farmers, and to some extent the operating engineers at the level which serves the farmers, have limited knowledge at best. The trade-off between electricity production and irrigation, reservoir factors, and capacity factors are all rationing devices at the level of releases into the system, which act to create an uncertain water supply. At the lower levels, the physical design of the system, the design of watercourse outlets, and especially the canal rotations and *warabandi* systems all interact to assure a relatively unpredictable water supply from the farmers' point of view. Indian agriculture has been described as a "gamble with the monsoon". In canal-irrigated areas it is a gamble with the canal as well.

In the context of modern agriculture in which the time of delivery of water may be as important as its amount, there are significant defects in the way in which water is delivered. Although it is extremely important with the new wheats to have water at the time of crown root initiation, to pick a particular instance for discussion, the farmer can neither control whether he will have water at that time, nor even predict whether he will. The element of uncontrollability is clear: the farmer has water available to him only when it happens to be flowing during his turn; it is quite easy for water not to be available for the restricted time during which crown root initiation takes place. He cannot *control* water delivery to insure its taking place when he needs it, even though he is supposed to get his share in the course of the season.

But even in the absence of *control*, if the farmer could *predict* water timing in a particular year, he could choose his crops and the planting, fertilising, and watering schedules they imply in such a way as to make the most of the water when he does get it. In the particular instance we have chosen, if the farmer could know that he was assured water at the time of crown root initiation for the new wheat, he could pick his crop and sowing date in a way which would take maximum advantage from the fact. In the absence of such assurance, he might well be better off planting a crop with lower potential yield under assured irrigation, but higher potential returns under water stress due to random irrigation.

In the restricted areas with which we are acquainted, even the element of predictability is lacking. Although it seems that the rotations among channels could be known in advance, in fact this knowledge does not appear to be made available to the farmers, even though the knowledge would enable them to predict whether or not there would be water in the watercourse at the time of their turns. It seems clear that the combined lack of control and lack of predictability must influence cultivators adversely, and indeed they make this situation clear in discussion.

We can see the response of farmers in two ways: the first is that they change the operating procedure to suit themselves, in conflict with the law and the regulations framed under it. The second involves the use of new technology, the tubewell.

The farmers change the operating procedure by trading water among themselves, both within seasons and between seasons. In this way, for example, a farmer who gets two successive irrigations may trade the water in his second irrigation turn to a farmer who has had several successive dry turns, and can thus benefit from the second irrigation to a greater extent than the first farmer can. The second promises repayment later in the season—or conceivably even in the next. Farmers in field interviews have described both intra-seasonal and inter-seasonal trading.

Water trading and sale are illegal, except with the permission of the Superintending Engineer.[3] He supervises an area of possibly a million acres or more, so his accessibility is obviously low. It can hardly be easy to obtain the relevant permission, and it was clearly not intended that it should be; the provision for permission is for exceptional cases, not for matters of routine. Apparently canal officials generally ignore or are unaware of practices of trading and sale; but since the practices are formally illegal, exchange of water can be practised only with a restricted set of people in whom one has confidence, since reciprocal obligations cannot be legally enforced and risk is thus high. Existence of the practices of trading and sale is thus strong evidence of the demand for timely water.

The second response of farmers to uncertain canal water supply has been to install tubewells. The option of course is restricted to areas in which the groundwater is sweet and relatively close to the surface, say 30 to 40 feet. Surveys of farmers who have installed tubewells invariably indicate that they see predictability and controllability of water supply as among the leading virtues of tubewells.[4] The tubewells offer of course greater supply, but the farmers are quite clear about the value of water delivery on schedules which match the demands of their crops which cannot be exactly known in advance, because of variations in rainfall and temperature, for instance. Since the farmers own the tubewells, they can put water on the fields when they want.

The farmers' reaction to the canal water distribution system certainly indicates that something is wrong: their attempts to change the pattern of delivery to match the requirements of their new crops clearly indicate that the system does not "supply the required quantity of water at the right time on the farm".

In the context of the problems we have just discussed, the historical development of the system is not simply an antiquarian curiosity. The form which the system took was based on social and economic forces which in many instances still prevail. Any discussion of desirable changes in the way water is distributed and applied to the land must deal with the reasons why the system is the way it is and provide ways of dealing with the real problems *and* with the anxieties which both canal officials and farmers will feel if the Government undertakes substantial change.

The canal systems in North India were set up by and large to prevent famine, at a time when it seemed more effective to spread the water thinly to provide each district a measure of famine insurance rather than to depend on transporting grain from surplus districts to deficit districts in this largely pre-railway age. The ever-present threat of famine was the driving force behind Government irrigation; deaths numbered in the millions when the rains failed. For instance, in 1866, just at the beginning of a wave of spending on irrigation and the consolidation of Governmental irrigation policy, the Government of India estimated that over one million people died of famine in Orissa in a single season.[5] Under pressure from outraged public opinion, the vast amount of human misery, the costs of famine relief, and the loss of revenue from failed crops, the Government of India placed great emphasis on the delivery of some amount of irrigation water to every district in which supply was feasible. A fundamental memorandum by Colonel Richard Strachey, written in

1867 when he was Inspector-General of Irrigation, sets out a summary of the thinking behind the policy of the Government of India:

> It appears to me that the Government having now adopted the policy of extending irrigation generally, and so far as it is possible in a manner that shall to the utmost guard against the worst effects of severe drought... in every canal, at the earliest possible period, an allotment of the available supply should be made on fixed principles to the districts traversed by it.... The first limitation of the supply of water would be with reference to the proportion of the culturable area within the reach of each canal, for the irrigation of which a provision of water should be made. This proportion might either be fixed at one uniform rate for the whole canal, say one-third or one-fourth of the culturable area, or the share of water might be made to vary in some measure according as the several districts were more or less favorably situated as regards rainfall, or the natural facilities for well-irrigation.... A certain normal standard or proportion of irrigated area should be regarded as claimable by every district to which water can be given.[6]

Strachey makes quite clear—in this quotation and elsewhere in his memorandum—that what was primarily before the eyes of the Government of India was a question of *equity*, of giving a proportionate share of the available water to each acre of land which would be able to use it. He had quite clearly in mind that in a developed canal system the available water would never be enough to give full supply to any farmer's land. Apparently modern systems follow Strachey's recommendations. The planned irrigation intensity of India's Bhakra system is 62 per cent annually,[7] or about one-third of the canal service area for each season.

So the first major consideration in the system was set. The motivation was to distribute water in such a way as to maximise insurance against drought, rather than to maximise production. And this insurance against drought was bought by getting some water to all the land under the command of a canal, although Strachey anticipated that water would then be concentrated by individual farmers on one-fourth or one-third of their holdings.

The next issue is the controllability of the supply. There is strong reason for thinking that controllability of supply at the local level was knowingly avoided by those who designed the irrigation system. The water allocation spoken of above in itself implies low control in times of drought, that is, just at the time when the marginal value of the water would be highest. But there were factors beyond design which worked against controllability. One of the principal ones was the avoidance of corruption, to which the British became quite sensitive. Richard Baird Smith, one of the great canal engineers of the nineteenth century in India, speaks of the power of subordinate canal officials: "incessant supervision is required to prevent these men from turning their power into money". The less controllable the supply was locally, and the more it was regulated by fixed rule and fixed rotation, the less the opportunity for petty officials to practise extortion on the farmers.[8]

This system has certain clear virtues —especially when viewed against the backdrop of an agriculture demanding less skill in timely water management than do present high-yielding varieties. Opportunity to receive water is rationed in a way which can be seen to be fair: each parcel gets its proportionate amount. The possibility of human intervention in the system is small, so the possibilities for corruption and favoritism are also kept small. The rules for distribution are public knowledge, and each farmer is sure of his rights —even though these are rights to an uncertain water supply.

One important way in which controllability might be attained in some measure—as we have already pointed out—would be if farmers could sell water to one another, or trade it, a procedure which has much the same implications. Early rules permitted the practice. Richard Baird Smith wrote in one of the first revenue reports of the Ganges Canal that:

> Contractors having more water than they can themselves consume are at liberty under Rule VIII to sell it to other parties not belonging to their own villages.... It seems not improbable that in such sales as are contemplated in this Rule, valuable indications of the true value of water may be obtained. If others are willing to pay what a Contractor demands for his surplus water, the price so paid is always worth noting, and may be useful to us whether it be in excess or deficit of what we charge ourselves.[9]

The difficulty embedded here (not the only one) is that a contractor would *have* surplus water. The Government of India was most anxious to see that no rights to water became established: water was the property of the Government to be disposed of for the common good, as the Government saw fit. The stipulation of "no rights" was necessary precisely in order to achieve the objective of rationing the water among present and future claimants. The Government of India was quite explicit about this principle, several years in advance of legislation enunciating it clearly:

> The Governor General in Council thinks it very necessary to guard carefully against the possible growth of any legal rights on the part of cultivators or land-holders, adverse to the exercise on the part of the Government of a full discretionary power of distributing the available water as shall seem to it best for the general interests of the community as a whole.[10]

The conflict of the possibility of sale with the Government's discretionary power over water is clear: water deliveries were to be based on what people could use. By definition, if a contractor were receiving water which he could sell, he was receiving more than he could use. If he continued undisturbed in this right, he might somehow acquire a legal right to the excess water, enforceable through the Courts, or at least a troublesome claim on the water. The result was apparently the prohibition of water sale and trade now embodied in the law.

The existing system which spreads water thinly among farmers rather than providing a few with sufficient water to irrigate all their land is clearly here to stay. Certainly the present system enables a more nearly equal distribution of income—which is a stated national objective—than would a policy of water concentration. The primary difficulty, in our view, lies not so much with the relatively limited supply for each farmer, since that merely means that more farmers share in the water, and can concentrate it optimally on their own land. Rather, the principal problem is the lack of predictability, certainty, and controllability of the canal water supply by the farmer. These difficulties directly affect his yields and returns per acre.

In terms of the income equality objective, one might even suggest that water should be shared equally among people instead of among acres, as at present. What useful purpose is served by distributing water according to the amount of land held by individual farmers? If one traces the idea back to the Strachey memorandum of 1867, for instance, one finds him referring to "the *equal natural right of all irrigable lands to share alike* in an advantage brought to them without any effort or outlay on the part of their occupants...". To make land rather than individuals the possessor of natural rights seems a peculiar perversion of

eighteenth-century political philosophy. It seems even more so in the modern context, when a major worry in current agricultural policy is the impact of the Green Revolution on the small farmer and his possible displacement from the land.

It seems to us worth serious consideration whether it might not be better to allocate water to some extent to individuals rather than to land area, so that small farmers would be entitled to more water per acre than large farmers. This objective of doing something to strengthen the position of the small farmer would not necessarily be in conflict with efficiency objectives. Indian data from many areas indicate that small farmers apparently operate at no disadvantage in productivity per acre; some observers are even inclined to credit them with higher per-acre productivity.[12] If the small landowner is going to be squeezed by the new technology (we need not necessarily concede the point at this stage), one way of combatting the problem without loss of production would be to ensure him enough water to be able to compete effectively against larger farmers. The proposal is hardly without its political difficulties, but neither is the alternative, if that is forcing small farmers into the city or into the ranks of landless agricultural labour, as Indian and Pakistani political leaders are increasingly aware.

Apart from changes directly related to income distribution—which of course are controversial—what changes are possible and desirable within the system as it exists? Let us begin with the simplest. As the system runs at present, it seems to us that there would be gains in productivity simply if knowledge were increased. If farmers could know the timing of at least a portion of their water deliveries for sure at the outset of the season, they could make better plans for the type of crop to be planted, time of planting (which is often variable by weeks), fertilisation, and other critical decisions. It seems to us that this knowledge could be given at trifling cost. Indeed, it is apparently supposed to be, but our informants indicate that it is often not. If farmers knew the Rotational Programme of Channels, they could combine this knowledge with the *warabandi* to predict at least some of their deliveries.

To some extent of course, the insecurity about water delivery is the result of the engineers' not knowing what the flow at the canal head will be. We do not presume to know the answers in this area, but would it not be feasible to schedule some secure minimum supply for each farmer for periods of time known in advance? Perhaps engineering requirements and uncertainties would make such a practice difficult if tried simultaneously everywhere on a canal. The issue needs more exploration. But surely it would be an improvement if secure deliveries would be promised even on a rotational basis, by season or year, so that, say, one-third of the farmers in any given year would have promised secure deliveries of water large enough to be significant at critical times. The group of farmers to be allowed this security could change in every year, so that "secure water", if we may term it that, would be rationed out by turns. The system as it exists now parcels out to everyone a measure of insecurity along with an amount of access to water, so that although the canal system as a whole will be certain to have water at periods critical for crop growth, no individual farmer on the system can be sure of deliveries.

Second, there should be some way of scheduling known water deliveries so that they have some connection with likely crop requirements. It might well be a mistake to approach this problem on an administrative level, partly because of the complexity of the problem. But thought should be given to it. Canal engineers are often sensitive to the problem, but they are seldom in a position to do anything about it. Their actions are constrained by a system designed to make operation as automatic as possible. In the context of the new varieties, however, the losses from automatic operation seem larger than when we think in a nineteenth-century context. What we need is a redefinition of the objectives of the system.

We have already indicated a device which would move some distance towards making water available when wanted, even without change in higher levels of the irrigation system. Water trading and water sale are not now permissible. Yet these devices permit those closest to the growing of the crops to determine when water is of value to them, and when it would be more advantageous to them to sell water or to advance or postpone its delivery as made possible by complementary needs on the part of others with whom water trading or sale is possible. In early discussion, the Government especially did not wish to permit acquisition of rights over *surplus* water. When we talk of water trades, we are talking simply of the farmer's changing the distribution through time of the water he is entitled to in any case. The historical record does not indicate that the British engineers even considered the matter of trading. What reason is there for its continued illegality?

Attitudes towards sale of water might be more difficult to deal with. At least one official of West Pakistan's Water and Power Development Authority has been heard to be highly critical of farmers selling water from private tubewells, on grounds that they are "exploiting" their neighbours (by offering them water for which they are prepared to pay!). It is clear that such feelings run deep, at least among certain people. Yet in a situation in which canal water is clearly underpriced in many areas, prohibition of sale means that lower-productivity users are compelled to use water to which they are entitled, rather than receive a share of the benefits of more productive water use by other farmers. Everyone would be better off if exchange were permitted. It is virtually axiomatic in economics that any arbitrary allocation—like that of canal water—can be improved by permitting uncoerced trading or sale. The initial distribution or entitlement can be done in a way which satisfies equity criteria, and trading or sale then can be permitted to allow farmers to improve their position as they see it, and consequently to permit higher agricultural production from fixed resources.

To protect the politically and economically weak requires the proper institutional framework. No doubt an element of the rationale for sale prohibition might be that the possibilities for coerced sale are considerable. But surely the possibility exists now for coerced water trades (or for unrequited swaps). The opportunity for legal sale or trade might help to insure that the farmer giving up water would be able to profit by so doing. Nevertheless, it might be well to prohibit permanent sale of rights to water, so that farmers would not alienate a source of future income which present ignorance, present technology, or lack of skill might lead them to undervalue.[13] But a complete prohibition of sale, softened only by the inattention of canal officials, seems to us to offer no advantages.

The idea of small-scale water sales and swaps within a given area may seem radical to those accustomed to a system which does not now include this feature, but a number of contrasting irrigation systems in various parts of the world include such practices. In Alicante, Spain, for instance, there are

semi-weekly sales of rights to the water of particular irrigation runs. Some of the water is sold privately by irrigators who own entitlements to water; some by non-irrigators who happen to own such entitlements. The *huerta,* the mutual water company, which owns some entitlements to the water of each irrigation run, sells these entitlements at public auction to pay for the operating costs of the system. A farmer selling water at one run of the canal from the reservoir is likely to buy rights for another run. Arthur Maass and Raymond Anderson have done simulation studies which indicate substantial advantages in the Alicante context of this sort of distribution system over other possible systems—including ones similar to those now extant in North India and West Pakistan.[14] In some parts of the United States as well water can be bought and sold, even in some cases between farmers whose land is served by different canal companies. Recent writing in the United States indicates that there is scope for increasing production and income through much more use of such water-transfer procedures.[15]

One possible development to facilitate sale and trading of water might be some form of water-users' association. The water-users' association—comprising all farmers on a given outlet or watercourse—could contract with the Government for timed delivery of water and then manage internally the problem of allocation among ultimate recipients, perhaps on the basis of purchase and sale or trade of water for particular irrigation runs. Irrigators—as now—could be initially entitled to water on the basis of land owned (with or without some preference for small holdings), but would be able to trade or sell water with other farmers on the watercourse when it appeared to their advantage to do so. Water available to the water-users' association above guaranteed deliveries might be auctioned or sold to farmers as is done in the Alicante system, the profits then to be shared among the members or perhaps devoted to watercourse maintenance.

The water-users' associations would have the advantage that they would be in a position to express a demand for water; a body large enough to be significant could represent the irrigators in their dealings with the canal authorities. As it is now, each farmer is obviously too small to make any difference, and of course has no feedback mechanism to register his demands with the authorities in any case. The water-users' association might be in a position to express a demand for more water by offering to trade, purchase, or sell water at various times with other water-users' associations, thus improving water allocation in a larger area than just that of the particular water-users' association.

The water-users' association would face the classic difficulty in rural India and Pakistan. What would prevent them from falling under the control of dominant landlords or caste groupings? Many observers attribute the scant progress of the co-operative system in India and Pakistan to just such difficulties. We need a great deal of exploration of such problems, in part through looking at analogous institutional structures in the Indian and Pakistani context, in part through examination of water-users' associations in other countries. (Taiwan presents an instructive example from the less developed world.) Experiment should certainly be on a small scale, and probably would be best undertaken in areas where landholdings are relatively uniform.

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The suggestions we have made are not necessarily the best or the only ones that one could make. Our primary interest is in stimulating discussion of the whole range of possible measures which might be brought to bear to improve income through better use of irrigation water, while still preserving (and possibly strengthening) the equity considerations with which the systems were initially designed. The set of mechanisms we have discussed obviously reflects our bias as economists. Engineers and agriculturists have much to contribute to the discussion and might well focus on other issues. The important point is that much more needs to be done by all groups concerned to serve the needs of the farmer for timely water supply on which he can depend.

Notes

1 Contemporary data on system operation underlying our generalisations are from Richard B Reidinger, "Canal Irrigation in North India: Microstudy and Evaluation" (Ph D thesis, Duke University, 1971). The study area was a portion of Hissar District, Haryana, under the Bhakra canal system. He is preparing portions of the thesis for publication. Historical materials are from a still unfinished study by Gustafson of the development of irrigation legislation in India. The present paper was written for an Agricultural Development Council conference on the evaluation of water distribution systems at Colorado State University in August 1971.

2 Preliminary data indicate that the amount of water actually received per acre does not correspond well with the amount of access time.

3 J L Jain (ed), "Northern India Canal and Drainage Act", second ed, (Chandigarh: Jain Law Agency, 1968), p 30. Section 5(e) of the Act reads in part: "Unless with permission of the Superintending Canal Officer, no person entitled to water of any canal, shall sell or sublet or otherwise transfer his right to such use..."

4 See for instance Ghulam Mohammed, "Private Tubewell Development and Cropping Patterns in West Pakistan", *Pakistan Development Review* 5:1-53 (Spring 1965). See also Programme Evalution Organisation, Planning Commission, "Evaluation Study of the High-Yielding Varieties Programme: Report of the Rabi 1968-69 — Wheat, Paddy and Jowar" (New Delhi: November 1969).

5. B M Bhatia, "Famines in India", second ed (Bombay 1967), p 69. The estimate was scarcely firm, but the order of magnitude was.

6 Colonel Richard Strachey, R E, "On the principles to be followed in determining the capacity of Irrigation Canals in Upper India; in regulating the distribution of the available water supply to the districts through which a canal passes, and to villages or individual cultivators; and in assessing the charge made for the water supplied for irrigation", 13 July 1867, in Proceedings of the Government of India, Public Works Department, September 1967, A80 (in Appendix), National Archives of India, pp 6-7, 11.

7 Nasim Ansari. "The Economics of Irrigation Rates: A Study in Punjab and Uttar Pradesh", (Bombay 1968), p 135.

8 R Baird Smith, letter of September 17, 1858 to Secretary to Government, NWP, in Parliamentary Paper 149 (HC) of 1861, p 14. Compare the following passage from a text which was standard in the training of Indian irrigation engineers: "What is required is a series of outlets in each distributary arranged so that each will deliver its full calculated discharge at the ordinary full water surface level, and that the discharges of all outlets will be proportionately reduced as the surface level is reduced. *This arrangement provides equitable distribution without any interference by the canal establishment —which is an important advantage to the irrigation community".*

J Clibborn, "Irrigation Work in India", revised by G T Anthony (Roorkee: Thomason College, 1924), p 146. The italics are ours.

9 R Baird Smith, "General Instructions on the Settlement and Collection of the Revenue, the Distribution of Water, and the Details of Police for the Ganges Canal", February 27, 1855, Appendix VII to Revenue Reports of the Ganges Canal for the Year 1855-56, in Selections from the Records of the Government of India, No XXI (Calcutta 1856), p ix.

10 Circular Letter Nos 142-3 I, September 13, 1867, from C H Dickens, Secretary, Public Works Department, Government of India, to Undersecretaries of the Governments of Punjab and North-Western Provinces, No A31 in the Proceedings referred to in note 6 above. The Governor General at the time was Sir John Lawrence.

11 Strachey memorandum, p 10. Italics ours.

12 See for example the long series of articles in *The Economic Weekly* for 1962, 1963 and 1964 by Raj Krishna, Hanumantha Rao, A K Sen, R G Agarwala, Dipak Mazumdar, and others. Most of the relevant references, along with much additional material, are contained in A M Khusro, "Returns to Scale in Indian Agriculture", in his "Readings in Agricultural Development" (Bombay, 1968).

13 Strachey is quite clear on this point: "It seems therefore to be the duty of the State to prevent to the utmost the less instructed and less energetic among the cultivators being deprived in the future of advantages which they may now be unable to appreciate, by reason of the more advanced portion stepping in before them, and first appropriating the whole of the limited water supply." Memorandum already cited, p 12. We should note that this remark was made in a situation in which the Government was having difficulty persuading farmers to take water.

14 The Alicante system is described and evaluated in a forthcoming book on water distribution systems by Maass and Anderson. Clements R Markham — in a book printed by the order of the Secretary of State for India — described daily sale of water on the Elche system in 1867; he says nothing about sale in Alicante, but indicates that its system was similar. The custom apparently dated from Moorish days. See his "Report on the Irrigation of Eastern Spain" (London: T Richards, 1867), p 52.

15 See B Delworth Gardner and Herbert H Fullerton, "Transfer Restrictions and Misallocation of Irrigation Water", *American Journal of Agricultural Economics*, 50: 556-571 (August 1968).