Water and Social Structure

I

THE BASIS OF COMMUNITY

RADHAKAMAL MUKERJEE

The partition of land is common everywhere but in some areas we find that water rather than land is the subject of careful partition and of a regular tenure on well understood conditions. This is the characteristic feature of the tenures in the North-West Frontier Province and in the districts in the south-west of the Punjab. In early tenures it is not so much the soil that is regarded as the subject of ownership as the produce. This may be the case, especially, where land is abundant and of little value until laboriously cleared of tall grass and jungle. A similar feeling regarding water arises in cases where the land, without means of irrigating it, would be absolutely useless. The principle of distribution depends on the amount of water available. When there is more than enough, every one extends his cultivation according to his means, and then gets water for the whole. But where the water is not superabundant, it is divided according to the inheritance-fraction which each holder represents in virtue of his place in the genealogical tree. Water-shares are in some cases (where the supply is very limited) sold quite independently of land. Thus, a man may have a piece of land dependent on rain only for its cultivation, and he may then buy a water-share, or perform labour and service to acquire it. Naturally such customs arise where cultivation is possible only by the aid of rainfall, but is so inferior, as well as uncertain, that an irrigation share is really the right which possesses the greater value. . . .

Water-Sharing and Human Solidarity.—In many parts of the world

Excerpted from Radhakamal Mukerjee, *Regional Sociology*, Century Co., New York, 1926, ch. VII.

we find men living in arid territories exploiting the water by means of an effective collective organization. Brunches observes:

'When men living in arid territories once wish to devote themselves to cultivation and seek to exploit the water they cannot but submit to that effective solidarity which water often imposes upon them. In several cases where the exploited water is furnished to them by a single source (spring, stream, canal or reservoir) and where this exploitation of the water has led them to ease and prosperity, they have clearly understood, or at least definitely accepted, this necessity of the collective union of individual interests.' . . .

In different regions the recognition of this common interest leads to those admirable 'hydraulic communities' of Valencia or of Msila; sometimes, as in Egypt or the Panjab to-day, the State is led to co-ordinate the interests of individuals . . .

In tropical Asia, too, the necessity for collective regulation of water-supply in the case of rice cultivation is an important factor which has contributed to the development and perpetuation of the economic and administrative organization of the village community. In Japan and Java, as in India, rice cultivation has encouraged a good deal of fluid communalism and association of labour and maintained the compact village communities for the common interests of agriculture. Everywhere rice cultivation demands a system of irrigation which can make good the loss of water by evaporation, by leakage and by the continual passing on of some of the water to other plots belonging to other farmers, which encourages co-operative habits of work. Thus there are in Japan, as in Java and parts of India, hydraulic engineering works, as remarkable in their way as those of the Netherlands, which have been the work of unlettered peasants working in co-operation. Tunnels for conducting rice-field water through considerable hills, aqueducts, reservoirs, etc., which are met with in Japan and, indeed, throughout the Far East, represent a vast amount of communal labour hardly to be met with anywhere else. There are also numerous irrigation societies (*suiri-kumiai*) and associations for the readjustment of fields (*kochi-seiri-kumiai*), etc., which had their origin in very remote times. Floods were of frequent occurrence. Hence the construction of dams and dykes was undertaken co-operatively. . . .

The above brief survey of the forms of property and their evolution in connection with natural conditions once again proves the need of introducing into economics the examination of the geographical

environment, which will be found to be a corrective of abstract sociological theory. 'Human Geography', writes Georges Gariel, 'is destined to review all the sociological theories that speculate about some sort of abstract man'. For example, the study of the different forms of ownership of water here examined does away with all *a priori* and absolute theories, both those that lay down as a dogma that individual property is the only form of property acceptable to human reason, and those that tend to a conception of state ownership as applicable to all the countries of the earth.

II
TECHNOLOGY, MANAGEMENT AND CONTROL

NIRMAL SENGUPTA

The Indigenous System of Irrigation in South Bihar

Climatic and Topographical Condition

Average annual rainfall in Bihar varies from about 1,000 millimetres in Patna to 1600 millimetres or higher in the eastern extremes of the state. The variability of rainfall is also higher in the western districts. Within this drier zone, the areas lying north of the Ganges—the districts of Saran and southern parts of Muzaffarpur—are protected to some extent by the water-retaining capacity of the new alluvial type of soil. The southern part of this dry zone—the districts of Patna, Gaya, Shahabad, south of Monghyr and south of Bhagalpur, commonly known as south Bihar—is composed mostly of old alluvial type of soil with very little water-retaining property, which dries

Excerpted from Nirmal Sengupta, 'The Indigenous Irrigation Organization of South Bihar', *Indian Economic and Social History Review* Vol XVII, No 2, 1980
Notes and References Omitted. Editor

up very soon after the rains. The ground-water table is very low in south Bihar, excepting in those parts adjacent to the Ganges; and wells can be dug out only with much difficulty. Lastly, the area has a marked slope from south to north which causes quick flow of water. In fact, the natural conditions are so adverse that regular cultivation in most parts of south Bihar is not possible if left to the mercy of nature. Yet south Bihar has been the cradle of a very ancient civilization, and has continued to remain one of the most populous tracts in the world for a period stretching over two millennium.

As will be evident from Table 1, only in south Bihar was the major part of the gross cropped area irrigated in both the years shown. The data for Monghyr and Bhagalpur must be understood in the light of the fact that the irrigation facilities in these two districts are

Table 1

Districtwise Irrigation by All Sources

District	Percentage of gross irrigated area to gross cropped area 1931	Percentage of irrigated area to net sown area 1971
Patna	55.25	58.59
Gaya	48.87	59.37
Shahabad	40.25	64.41
Saran	15.62	25.42
Champaran	7.35	18.11
Muzaffarpur	8.59	5.65
Darbhanga	5.81	8.65
Monghyr	18.77	16.11
Bhagalpur	17.31	34.39
Saharsa		22.84 12.25
Purnea	1.53	8.61
Santhal Parganas	17.33	3.64
Palamau	11.59	16.02
Hazaribagh	1.43	2.09
Ranchi	0.19	2.15
Dhanbad	N.A.	2.06
Singhbhum	14.75	3.87
Total Bihar	17.92	19.55

Source: 1961 Census (*a*) District Census Handbooks, Tables AS—IV, All districts (*b*) Agriculture Census, Bihar, 1971.

concentrated mostly in the southern parts. Table 2 shows the relative importance of the different sources of irrigation in the dry zone area during the first quarter of this century. Under the soil and ground-water conditions in Saran district, well-irrigation, involving little difficulties, was practised extensively. The Sone canal was constructed in the last quarter of the nineteenth century; and canal irrigation has replaced the old modes of irrigation in large parts of Shahabad district as well as in the eastern parts of Patna and Gaya districts. In the rest of south Bihar—in Patna, Gaya, south Monghyr and south Bhagalpur—the major modes of irrigation were from regular tanks and two

Table 2

Area Irrigated by Various Sources of Irrigation

(in early twentieth century)

Sl. No.	District/region	Percentage of net cropped area irrigated by					
		Govt. canal	Pvt. canal (pynes)	Tanks & ahars	Wells	Other sources	Total
1.	Shahabad	22.28	3.83	10.26	4.85	0.70	41.92
2.	Patna	2.23	21.62	24.35	6.80	4.93	59.94
3.	Gaya	4.29	15.96	26.83	5.98	1.77	54.83
4.	South Monghyr	..	6.94	19.64	3.63	12.38	42.59
5.	South Bhagalpur	..	16.51	5.54	1.21	12.77	36.03
6.	Saran	..	0.38	2.80	10.86	1.10	15.14

N. B.: 'It is difficult to say how far the relative figures for private canals (i.e. *pynes*) and *ahars* are correct since in many cases the two are interdependent. . . . In comparing the percentage of irrigation from different sources certain allowances must be made. In South Monghyr (Final Report, paragraph 137) and South Bhagalpur (Final Report, paragraph 207) a certain proportion of area irrigated from other sources should have been included in the area irrigated from private canals and *ahars*. In Shahabad (Final Report, paragraph 314) a certain proportion of area shown as irrigated from private canals is really irrigated from Government canals. It is probably judging from the figures given by the Canal Department reproduced in paragraph 41 of the Patna Final Report, that a similar mistake occurred to some extent in Patna also.

Source: Compiled from the different Final Reports of the Survey and Settlement Operations in South Bihar districts (1905–1918) by E. L. Tanner, *Final Report on the Survey and Settlement Operations in the District of Gaya, 1911–18*, pp. 136–7.

other systems peculiar to this area, namely *ahars* and *pynes* (called 'private canals' in the early statistics included in Table 2).

Description of 'Ahars' and 'Pynes'

Being bounded by Chhotanagpur Plateau in the south and the Gangetic valley in the north, south Bihar has a marked slope from south to north roughly at the rate of one metre per kilometre. Using this terrain condition, an *ahar* is made by erecting an embankment of a metre or two in height on the lower ground, generally the north side. From the two extremes of this embankment two other embankments are constructed so as to project towards the higher ground (generally the south), gradually diminishing in height as the ground-level rises, and ultimately ending at the ground-level. Thus constructed, an *ahar* resembles a rectangular catchment basin with embankments only on three sides. The fourth side—the highest ground—is left open for drainage water to enter the catchment basin following the gradient of the country. Unlike tanks, the beds of *ahars* are not dug out. Sometimes these are built at the end of drainage rivulets or artificial works like *pynes* further ensuring the supply of water. *Ahars* with sides more than a kilometre long and irrigating more than a thousand acres of land, are not by any means rare. But smaller ones are more common.

Pynes, on the other hand, are systems devised for utilizing the water which flows through the numerous hilly rivers flowing from south to north intersecting the whole country. For most of the days in the year these rivers remain almost dry, but turn rather suddenly into swollen torrents following heavy rainfall in the Chhotanagpur hills. But the slope of the country is so great, and the beds of most of these rivers are so sandy that the water is rapidly carried through the region or percolates down through the sand, within a few days returning the same old sandy look to those rivers. In order to prevent the waste of water in this manner, numerous artificial channels called *pynes* are led off from points facing the current of these rivers to the agricultural fields. Some of the biggest *pynes* are 20 or 30 kilometres in length, feeding a number of distributaries, and irrigating maybe a hundred villages. Since the beds of the sandy rivers of south Bihar are usually high, there is no need to make the *pyne* beds deep in order

to divert the water into those. Further, because of the gradual slope of the country, within a few kilometres from its beginning, the beds of the *pynes* rise to near the level of the ground to facilitate irrigation of the adjacent areas, while still retaining sufficient fall to ensure the flow of water from the rivers into it. To raise the water level to field level the *pynes* are temporarily blocked at suitable length. In this way some of the small rivers of south Bihar never reach any of the main rivers like the Ganges or the Punpun, and are completely dispersed by several *pynes*. Sometimes *pynes* are impounded into *ahars* at the end, ensuring storage of any superfluous water. Alternatively, small *pynes* are also led from *ahars* for distribution of water. Both *ahars* and *pynes* generally carry water during the rainy season, from July to September, and guarantee against the untimely or scanty rainfall, frequent in south Bihar.

In the course of his Bhagalpur trip, Francis Buchanan was not much impressed by these irrigation works. He had felt that in comparison to similar works (i.e. tanks and *anicuts*) in Mysore, the works in south Bihar were 'vastly more imperfect' which he conceded as happened 'probably because the necessity is not nearly so great' in south Bihar. He had, of course, admired the economy of water use by impounding *pynes* into *ahars* as a 'judicious plan, so much neglected in Mysore.' As he proceeded further from Bhagalpur to reach Gaya, much of his earlier reservations vanished. His earlier characterization was that no attempt had been made to construct perennial works in the south Bihar system, and the intention was limited 'to supply the fields in intervals of fair weather that occasionally happen during the rainy season, and for the first month after these [rains] cease.' While in Gaya, he learnt that 'both canals and reservoirs contain also so considerable a supply, that they enable the farmer not only to bring the crop of rice to maturity, but, by the means of above mentioned (manual water-lifts), enable him to rear a winter crop of wheat, barley, &c.' Thus, although apparently crude, the *ahar-pyne* system is a remarkable indigenous system making possible the best out of a very unfavourable natural condition. Apart from the irrigation facilities there is still another utility of the system which has rarely been investigated. Being a region in between Chhotanagpur Plateau and the Gangetic valley, south Bihar is very prone to floods. But the abundance of storage works as *ahars* and the large-scale dispersion of torrential flood water into the *pynes* has minimized the rush and speed of the flood water passing through south Bihar.

The *ahar* and *pyne* system of irrigation attained its highest development in the district of Gaya. The first Irrigation Commission (1901–3) had noted that in total 1,670,000 acres—more than half of the total area of the district—was said to be watered in this way. As will be evident from Table 2, nearly three-fourths of the total irrigation facilities in south Bihar (excluding Sone canal command area) were from *ahars* and *pynes*. Among the other methods of irrigation, well-irrigation alone was of some importance. But wells were constructed, maintained and operated mostly by individual efforts and raised few social problems. The discussion here will be restricted only to the *ahar* and *pyne* systems.

Method of Cultivation and Irrigation

To a ryot of Eastern Bengal the country would seem utterly unsuitable for rice cultivation, both from the nature of the surface and the comparative throughly the plants begin to deteriorate at a steady rate. Thus, although the cultivators expect late rains during *Hathiya* no one will risk practising *nigar* hoping for a timely rain. The need for irrigation from *ahars* and *pynes* is mostly felt during *Hathiya nakshatra*, and even if there is good rain during this time and little artificial irrigation is actually practised, the irrigation works go far as to increase the yield by encouraging the cultivators to undertake *nigar* operations. The late rains during *Hathiya* is crucial also for the sowing of the *rabi* crops. In case there is a failure in some year the cultivators exert their efforts to use up the last bit of water left in *ahars* and *pynes* for preparation of rabi fields for sowing, after irrigating the rice crop.

What great protection the *ahar-pyne* system of irrigation of south Bihar had lent to the tract can be understood from the fact that Gaya district, where the system reached its highest level of development, remained practically immune to famines while the rest of India suffered from several big famines. In the year 1866, the year of the so-called Orissa Famine, during the Bihar Famine caused by the untimely rain in 1873–4, and during one of the greatest famines in record, the famine of 1896–7, the district of Gaya required practically no relief, although the whole of the eastern region had suffered

very badly. It is however significant that the immunity to famines began to disappear once the irrigation works began deteriorating. There were several years of scarcity in the thirties of this century. Gaya district, in particular Nawadah sub-division, was in the grip of severe droughts and famines in 1950–2 and 1957–9. Lastly the famine of 1966 struck Gaya district with the same severity as it struck other districts of Bihar. Today Gaya is regarded partly as a drought-prone area, no more as an area immune to famines.

Like famines, Gaya district was also immune to floods in the heyday of indigenous irrigation. But in recent years that immunity too has been lost.

A Note on Antiquity of the System

The effective settlement of the middle Ganges Plain does not seem to have begun until the eighth and ninth centuries BC. It is suggested that the dense forest cover had probably delayed settlement of this region. The first evidence of rice being grown on the margins of the Ganges delta dates from 700 BC. The effective occupation was even later. By then the settlers had probably known plough and iron axes without which settlement of this forest region would probably not have been possible. It appears that another invention—the characteristic irrigation system of this region—contributed greatly to, if not the original settlement, at least the extensive and dense settlement in this region. The *ahar-pyne* system of irrigation was already well in use during the time of the *Jatakas*. The *Kunala Jataka*, written in this area, mentions that canals were excavated communally and served sometimes as demarcation lines between two neighbouring properties, that the use of this commonly owned water often gave rise to keen dispute, that it was not uncommon for the course to be diverted in the direction of one village's fields at the expense of another's. In such cases violent quarrels resulted which developed occasionally into pitched battles between rival villages and the disagreement had to be brought before the local council for adjudication. The description sounds as if it is happening in a south Bihar village in modern times.

In the *Arthashastra* there is reference to *aharyodaka-setu* as a method used for irrigation. The word *para* (see *parabandi* later) is also found in the same book as a regulation for the violation of

which persons shall be fined 6 *panas*. However, *para* and similar words (e.g. *wara* in Punjab) are still in use to describe the rotational arrangements in irrigation not merely in south Bihar but also in many other corners of India. Megasthenes' description too confirms the existence of closed canals in Bihar, from which water was distributed in the conduits for the purpose of irrigation. It must be understood that even if such earthworks had existed quite extensively in ancient times it would be impossible to find any trace of those in archaeological excavations. On the other hand, it may not be very surprising if some of the surviving works happen to be so old.

Social Organization

Such a society, with irrigated agriculture based on large irrigation works, has to accomplish several social tasks peculiar to irrigation. There is a set of technical tasks relating to planning, construction and maintenance of irrigation works. There is a set of relations necessary for the control and allocation of water among the users for meeting the cost and labour required in carrying out the technical works, for resolution of conflicts and even for organization of rituals, if any. Both Julian Steward and Karl Wittfogel had made the drastic generalization that the irrigation works in traditionally irrigated societies were centrally organized, requiring complete control over labour power. This gave rise to bureaucratic management, from which emerged a bureaucratic state power, despotic in its nature. Thereby resulted 'a state stronger than the society', and consequently, social relations were determined according to the needs of the despotic state, and were delegated to social classes by the state power. However various studies indicate that the social organizations in such irrigated societies are not as strongly modelled as suggested by Wittfogel, and that there are various aspects of social relations which deserve special attention. In this paper I will restrict my discussion to the production relations between the cultivators and their overlords, and only to those relations which arise because of the irrigation works. The relations among the individual cultivators, among the artisans, labourers and cultivators in the irrigated villages, among the residents of different villages using the same source of irrigation—all of which form interesting and important aspects of social relations—are not dealt with here. Further,

the availability of data imposes restrictions on the period of inquiry in this study. The discussion here will mostly be confined within the period of colonial rule. However, there is an interesting aspect within this period—there occurs a transformation of the social organization of irrigation in south Bihar. In the following section of the article that transition will be the major focus.

Physical Aspects of Organization

Hunt and Hunt inferred, from a review of the various studies on indigenous social organization of irrigation works, that the social organizations at higher levels are involved in matters of infrequent decisions, e.g. construction, repair of major areas of conflict including external conflicts. The areas of interaction between the village communities and the overlords—the *zamindars*, in south Bihar—with respect to irrigation works were more or less the same. During the *zamindari* days, the responsibilities of construction and maintenance of the *ahars* and *pynes* lay mainly with the *zamindars*, although there is no mention that they were responsible for similar works on the smaller distribution channels emanating from *ahars* and *pynes* and for distribution of irrigation water within the villages. Most of the *ahars* and *pynes* were very old and how these were constructed cannot be asserted, although officials have been emphatic that they were constructed by the *zamindars*, presumably inferring this from the records of construction of the few works undertaken in the nineteenth century. Fragmentary references to the modes of operation of the *zamindars* in matters of construction and maintenance are available. 'The expenses both of making and repairing the canals and reservoirs is entirely defrayed by the zamindars' observed Buchanan. Besides, there was a collective system called *goam* in which every cultivator had to supply one man per plough to turn out on certain occasions and carry out the physical works. But the *zamindars* had the responsibility of organizing such collective work by fixing and announcing the date of *goam* and even by forcing the unwilling to participate in such matters. The maintenance works need to be carried out regularly. Being crude earthen high silting of the hilly rivers and the methods of diversion of water by various ways of cutting the embankments. If repaired regularly, these works do not involve very great effort either in manpower or in finance. But negligence results into quick deterioration of these crude works, so much so that within a few years, even the trace of an old work may be difficult to locate. The smaller parts of these repair works, the negligence of which would affect only a few plots were probably done by the interested cultivators themselves. The responsibility of the *zamindars* lay more in organizing works which involved the interests of several villages.

Allocation of water within the villages was managed mostly by the cultivators themselves. Allocation between villages was a major source of conflict, and was a concern of the *zamindars*. Buchanan wrote that the *zamindars* would 'appoint proper persons to divide the water among the tenantry.' More detailed description is obtained for the later period. There was a system called *parabandi* by which the distribution of water among the villages from a common source (usually *pyne*) was regulated. Usually *parabandi* arrangements began in the month of *Aswin* (mid-September), when the demand was acute and the supply limited, and lasted for a month or two. At other times of the year it was usual to leave all branches of *pynes* open and let anyone use the residual water if one could. The *parabandi* arrangements consisted of more than one cycle of watering. Beginning from any one side of the *pyne* each village had its quota fixed either in the number of days or in the number of hours, thus assuring fair distribution to all the villages. After the completion of one cycle, the process was repeated in the same order (i.e. another cycle began) approximately after a gap of two weeks. In the principal *pynes* in Gaya district there were written regulations for *parabandi* arrangements. The Tikari Raj, the major *zamindar* family of Gaya, had in its possession an elaborate register called *lal bahi*, specifying the rights of each village enjoying irrigation facilities from such important *pynes*. For other smaller works, the regulations were mostly customary, until the beginning of this century....

Canal Irrigation and Ecological Change in Colonial North India

ELIZABETH WHITCOMBE

. . . The great nineteenth-century developments in canal engineering were concentrated largely in the Doab. They began early, in the 1820s, with the building of the East Jumna Canal. This system, a radical re-development of an old Mughal canal line, was opened in 1830. It irrigated tracts in the Saharanpur, Muzaffarnagar, and Meerut districts. By 1878, its main and branch channels, together with distributaries, totalled 748 miles and irrigated 206,732 acres (as against the average of the preceding five years, 188,648). The cost of the works, excluding interest, came to £ 261,235. One of the most remunerative canals of British India, it paid nearly 23 per cent on the capital expended on it by Government.

Irrigation in the grand manner began, however, with the Ganges Canal. The works were begun under Government order of May 1847, water was admitted into the canal in 1854, and irrigation commenced the following year. In 1861–2, the area irrigated by the canal was officially set at 372,000 acres; in 1864–5, it was set at 350,000 acres (the area under canal irrigation had contracted in comparison with the figures for 1861–2 as a result of good seasons and adequate rainfall). By 1864–5, the canal works as completed comprised its main line (181 miles); the Fategarh Branch (82.5 miles); the Bulandshahr Branch (45 miles); the Cawnpore Branch (170 miles); and the Etawah Branch (170 miles)—a total length of 648.5 miles with 2,266 miles of distributaries. The total capital outlay thus far was £2,155,997—by 1866, capital expended on the canal stood at more

Excerpted from Elizabeth Whitcombe: *Agrarian Conditions in Northern India Vol I, The United Provinces under British Rule, 1860–1900*, University of California Press and Thomson Press, 1971, pp. 64–85.

Notes and References omitted. Editor.

than 88 per cent of total expenditure of British capital in the North Western Provinces (NWP) since 1858. So far, only Upper Doab districts were served by the canal. In 1868, on the proposal of General (later Sir) Richard Strachey, the construction of a Lower Ganges Canal began, together with modifications in the completed channels. By 1877–8, the area actually irrigated by the whole complex was set at 1,045,013 acres (as against the average of preceding five years: 906,036). Some 593 miles of main and branch lines had been completed by then in the Upper and Central Doab. With another 3,417 miles of distributaries, the total length of the channels constructed ran into 4,010 miles, and the cost, excluding interests, stood at £3,055,015.

In 1868, the first works—sanctioned for the purposes of famine relief—began on the Agra Canal. In March 1874, the canal was formally opened and irrigation began the following *rabi* season. By 1877–8, it commanded an area of 375,800 acres altogether—114,200 acres in Muttra district and a further 113,100 acres in Agra made up the proportion irrigated in the NWP. Smaller works in Bijnour, fed by a stream in Moradabad district, covered an area of 4,000 to 5,000 acres. On a capital cost of £ 6,996, the Bijnour Canal paid 11 to 12 per cent: 'it has always been a remunerative little work', was R. B. Buckley's comment. In Bareilly, a further group of some four channels, totalling 256 miles in length and known collectively as the Rohilkhand Canals, irrigated a belt of country along the terai where rice was grown extensively. The capital cost was £148,207, on which only a small percentage had been realized by the end of 1870s. A series of small watercourses in the Dun, and south in Bundelkhand, fed by tanks and streams, completed the network of canals in the NWP: some 5,601 miles of channels and distributaries, irrigating in 1877–8 an area of 1,459,938 acres, by which time the cost of their construction, excluding the payment of interest, came to £4,338,384—all of it borrowed in England.

Works continued on the modifications and extensions to the Ganges Canal, as projected. After 1878, further works for the protection of unirrigated tracts specially liable to drought were thenceforward to be closely scrutinized by Government, 'in the light of the latest knowledge', with rigorous attention to the 'financial liabilities of the execution of works'. On these principles, General Richard Strachey, as President of the Famine Commission of 1878–9, recommended immediate and special enquiry into two schemes

which had not yet been implemented: the Sardah Canal to be constructed in Oudh and Rohilkhand, an elaborate project first prepared by Major (later Colonel) J. G. Forbes, R. E., in 1871, and a system of canals to be supplied from the rivers Betwa and Ken in Bundelkhand. The Sardah scheme was shelved in the face of opposition by both the talukdars of Oudh and the Chief Commissioner. Work on the Betwa Canal however, owing to pressure to provide relief for famine distress in the conventional form of temporary employment on public works was begun early in the 1880s.

Accurate statistics cannot be given of the overall increase in irrigated area owing to the canals. Acreages fluctuated with the seasons, the irrigated area expanding vastly with the threat of drought, to contract again in seasons of adequate rainfall. The question of payment of water rates also affected the area under irrigation during each season. In tracts where the cultivators were dependent on the canals, times in the *fasli* year when measurements were taken varied from district to district, pargana to pargana, and even mauza to mauza, thwarting any attempt at the compilation of a comprehensive statistical record. The period over which the increases in area were to be measured also posed a problem which was insoluble given the recording procedure used. Time limits were fixed according to the dates of revenue records compiled under Regulation IX of 1833: the period within which measurements were taken varied therefore from district to district, in the order of their settlement. In many cases, no statistics of irrigated area existed prior to the revision of settlements beginning in 1860. Further, both the earlier and revised settlements made no distinction between 'irrigable' and 'irrigated'. In 1884, W. C. Benett noted that an enquiry by the director of Agriculture and Commerce 'showed that [in several Doab districts] the settlement statistics are of no use in ascertaining the irrigated area, lands within irrigating distance of a well or tank being included in the actually irrigated area . . .'. Lastly, the problem of inadequate statistics is complicated by discrepancies in the percentage of increase in irrigated and in cultivated areas given in the various official sources.

Canal development was concentrated in those areas where facilities existed for it—that is, in western districts of the NWP. Those districts had a long-established and sophisticated pattern of farming, in which well irrigation particularly played a large part.

Colonel Baird Smith estimated that in 1848–9 the number of *pakka* (masonry) wells in the NWP came to some 137,337 of which 72,523 were in the Doab. Devastation during the 'Mutiny' brought this latter number down to close to 70,000, with each well having an irrigating capacity of approximately 4.5 acres per season. The corresponding number of the more common *kachha* (temporary) wells was estimated at 280,000, each with an irrigating capacity of 1.5 acres per season. From this, Baird Smith concluded that some 1,470,000 acres in the Doab were irrigated by wells in 1860–1. As the number of wells and their relatively low irrigating capacity would suggest, the Doab districts were densely populated by the latter part of the nineteenth century. Table 1 gives the density of population for selected canal-irrigated districts for which figures are available from the settlement reports.

Table 1

Density of Population for Selected Canal-Irrigated Districts

Canal	District	Population per square Mile[a]
Ganges, East Jumna	Muzaffarnagar (1872)[b]	415.9
Ganges	Bulandshahr (1865)	719.5
Ganges	Aligarh (1882)	548.0
Ganges	Etah (1872)	465.0
Ganges	Mainpuri (1872)	452.0
Ganges	Etawah (1872)	395.0
Ganges	Cawnpore[c] (1872)	442.0
Ganges	Fatehpur (1872)	419.0
Ganges	Farukhabad (1871)	534.0

[a] According to the census of 1872, the average density of population for the NWP was 381.24 per square mile.

[b] The dates in brackets are those of the various settlement reports used.

[c] Excluding Cawnpore city.

For its part in supplying this dense population, the well irrigation of the Doab was not regarded by Baird Smith and other official observers trained in engineering as wholly inefficient. He himself noted, significantly, that the effects of wells were 'less open to doubt than those of canal-irrigation', whilst the labour required to work the wells ensured the maximum use of water drawn; it was clear also that 'the produce from land under well-irrigation is generally larger and better than that watered in any other way'. The only trouble with the wells was that they did not produce enough. The land had to be induced to produce more, and to achieve that the canal system had to be expanded. Baird Smith confidently anticipated that in time canal irrigation would show results comparable to those of the wells, and that over the enormously increased area opened to irrigation by the canal system, 'existing differences in relative value will disappear .

In Meerut, the richest of the Doab districts, irrigation prior to the introduction of canals had 'naturally coincided very much with the character of the soils', E. C. Buck noted in 1874 in reviewing the settlement report. As a general conclusion from the pargana reports, it was clear that wells could be dug more easily, and lasted longer, in proportion to their distance from the great natural drainage lines: 'the best well tracts were on watersheds'. It was precisely these tracts which the new canals covered most extensively—canals being 'only serviceable for irrigation along the watersheds of the district'. The East Jumna Canal opened in 1830, supplied the 'rich Jat country between the Jumna and Hindun with a close network of distributary channels'. The main line of the Ganges Canal, opened in 1855, ran through the centre, level tract between the Hindun and the Kali Nadi, whilst its Anupshahr Branch, opened five years later, fed the comparatively narrow but fertile strip between the Kali Nadi and the Ganges. The division between areas with high proportions of better soils and the poorer tracts intensified: parganas Puth and Gurhmukhtesur, where widespread irrigation by wells was impracticable owing to the predominance of *bhur* ridges, also lay outside the range of canals and remained unreclaimed, whilst the extension of irrigation through the naturally fertile areas—for example, the central tracts of parganas Jalalabad and Baghpat—was reported by the end of the 1860s to have produced immediate and extraordinary increases in production. Where the

soils were of the stiffest composition, well construction remained at least theoretically possible alongside the introduction of canals. In pargana Kotanah, to the north-west of the district, channels of the East Jumna Canal covered almost the entire area, yet good wells could still be readily constructed. This was reassuring: 'In case of any accident to the canal, there could not possibly be any danger to the imperial revenue, for temporary wells could be dug in every field at trifling expense.' The supersession of wells by the canals, which immediately commanded a much greater area was said to have saved Kotanah and neighbouring parganas—the core of the opulent estate of the Begam Sumroo—from the ravages of famine in 1860–1; indeed, 'the proprietors' (chiefly Jats) made enormous profits from the grain trade. To the south, pargana Dasnah benefited similarly from the Ganges Canal.

Elsewhere, however, disadvantages and even deleterious effects of the canals were already becoming noticeable by the end of the 1860s. The growing dependence on canal irrigation brought its problems. In 1866, W. A. Forbes noted that in pargana Chaprauli, which he, like Sir Henry Elliot thirty years before, agreed to be the finest in the district, the inroad of canals had left most wells in disuse and that well-sinking was now 'almost entirely abandoned. It would be fortunate', he cautioned, 'if the people would take further advantage of the natural facilities for well-irrigation, and thus guard against the uncertainties of canal-supply—a precaution some of the enterprizing Jat proprietors in the neighbourhood have already begun to recognize.' J. S. Porter noted the advantage the canal brought to pargana Sirdhana in that it enabled 'sugar and other more valuable products doubtless to be grown in greater abundance'. But against this 'is to be placed the uncertainty of the water supply and the utter dependence on the canal to which the people are reduced by the ruin of their wells'. Several villages in the pargana had already sustained loss from the canal's (or its distributaries) interference with natural drainage: two had lost their entire *kharif* owing to flood water which had swamped the fields because its outlets had been obstructed by the canal; a considerable part of another mauza just beneath the canal bank was so swamped by percolation as to be unfit for cultivation. In other areas—parts of Baghpat, for instance—puddling was the inevitable consequence of the volume of water made available from the canal, far exceeding that supplied by wells and distributed by flush irrigation. Problems

of soil saturation were imminent. Buck, however, noted with reassurance in 1874 that it was 'entirely within the Government's power to alleviate or entirely remove these evils'.

Wherever canal irrigation had been introduced, the same—or similar—benefits accrued, as well as the same problems. If the driving principal behind the construction of the canals was the achievement of increase, without which no real prosperity could be envisaged, this aim was certainly satisfied, even if its exact measure remains out of reach. But in which products was this increase realized?

The overwhelming majority of the population—the peasantry—relied on the *kharif* millets, principally *jowar* and *bajra*, and the various pulses for staple food grains. These and fodder for draught beasts were generally grown on the wider areas of middle- and even poor-quality soils dependent for their moisture on periodic rainfall; irrigated land, of better- and top-quality soils, was used for the heavier and more valuable crops which required careful attention and a number of waterings in addition to rainfall for good yields. The expansion of irrigated and irrigable areas through the introduction of canals resulted in the increase in production of these 'valuable' crops—principally cotton, indigo, sugar cane, and wheat.

In the trans-Jumna parganas of Muttra district before the building of the Agra Canal, the principal *kharif* crops were *jowar*, *bajra*, and cotton, and the chief *rabi* staples were barley, gram, and *bejhar* (mixed barley and gram). The canal was confidently expected to alter this, in favour of the 'richer' crops. Whilst the area under cotton would be little affected, the pattern of cereal cultivation would show significant changes—'the substitution of irrigated wheat [encouraged by the relative richness of soils in these parganas], bejhar or barley for either *jowar*, *bajra* or unirrigated *rabi* crops.' The next stage would be the introduction of sugar cane, indigo, and opium—all hitherto almost unknown in the area—and an increase in *kachhiyana* (garden produce); double-cropping would become prevalent. 'There will then be not only an improvement in the quantity but also in the quality of the produce,' that is, the balance of the crop pattern would turn against the coarse staple food grains. These anticipations were realized. Two or three years later, R. S. Whiteway recorded in the settlement report that sugar cane had in fact been planted extensively along the canal distributaries; the coarser *kharif* crops, such as *jowar*, had in fact been 'greatly

superseded by the more valuable ones', including cotton, and even indigo had been sown in some villages. Of the canal-irrigated area of the parganas, 69.4 per cent was recorded under *rabi* crops in the year of revenue survey as against 26.4 per cent under *kharif*: *wheat* occupied 26.2 per cent, *barley* 12.3 per cent, and *bejhar* 21 per cent, compared with *kharif* staples of *jowar*, now only 9.7 per cent, and *bajra* 4.1 per cent. Throughout, the valuable crops of cotton, wheat, and barley alone accounted for some 39 per cent of the canal-irrigated area; in the cis-Jumna parganas, untouched by the canal, these crops aggregated a mere 23 per cent of the total cultivated area. Etah district, too, showed a crop pattern generally characteristic of canal-irrigated areas, which were most extensive in the Meerut and Agra divisions of the NWP: the best districts, supplied now by an abundance of canal water, went over to producing larger quantities of the most saleable crops. In Etah's *kharif* harvests sugar cane, cotton, and indigo predominated, and in the rabi, it was wheat, barley, and bejhar once again. In pargana Mahrehra—the best in the district—the Cawnpore Branch of the Ganges Canal had brought an immense stimulus to indigo growing: almost every village had its factory.

The distribution of wheat itself became one of the clearest indications of the direction in which the stimulus of canal irrigation was applied. In 1876–7, the total area under wheat throughout the NWP and Oudh was officially estimated at 5,902,770 acres, with 2,257,344 acres in the Ganges-Jumna Doab, as against 2,695,730 in the considerably larger area between the Ganges and Gagra which was barely watered by canals. That year, the acreage under wheat for the whole of Oudh was recorded as some 1,904,798 acres; and in Meerut Division alone, one of the great canal-irrigated regions of the NWP, wheat was said to be grown on no less than 1,371,103 acres. It was well known that wheat was 'not the food of the masses. They live either on the millets of the autumn crops or the coarse mixed grains (barley, gram, and peas) of the spring harvest. The urban population undoubtedly do consume a large proportion of wheat for their numbers; and the richer proprietors or tradesmen in the villages also use wheaten flour. But to the millions wheaten flour is a luxury, untasted perhaps from birth to death or only at high festivals and holidays.'

Given these conditions, we may ask what sort of protection the canals offered in the event of drought. When the summer rains

failed, it was the staple *kharif* grains and fodder crops which suffered; where the winter rains were insufficient, it was the poorer *rabi* crops. Canals were used to redress the balance only in dire emergency, and the growing of *kharif* foodgrains on canal-irrigated lands was never sustained once the immediate pressure of severe scarcity had eased. The famine years of 1868 and 1869 in the NWP exhibited a pattern which was to reappear whenever the rains failed. At the beginning of the drought, Government issued a circular encouraging the sowing of grain and fodder crops in canal-irrigated areas. This resulted, according to Frederick Henvey, in a considerable increase in areas cultivated with miscellaneous grains, 'though cultivators at first were very reluctant to water food-crops at the expense of other more remunerative produce'. It was not until August 1868, when the destruction of the *kharif* harvest was clearly imminent, that a rush for water took place. 'The fact is, as has been stated in the Irrigation Report for the year 1868–9, that farmers will only take canal-water to save, not to improve, the coarser grain-crops.

The disastrous failure of the summer rains of 1877 in most districts of Meerut, Agra, Rohilkhand, Sitapur, and Lucknow divisions, and in parts also of Allahabad, Jhansi, and Rae Bareli districts, destroyed the *kharif* food and fodder crops. The enormous deficiencies in out-turn could not be supplemented by canal irrigation, even where such existed, since, 'at the sowing season, cultivators could not foresee the terrible drought that was to prevail, and did not avail themselves of canal-water for this class of crop, the canal-irrigated lands being principally devoted to sugar cane, indigo, and cotton'. W. R. Burkitt saw how, in Etawah, sugar cane and indigo were gradually ousting food grains in the canal tracts and why this should give cause for alarm rather than the enthusiasm for increase so commonly expressed amongst his colleagues in the service: 'During the late drought [in 1877], when I was out inspecting the condition of the country, it was to me a most melancholy sight to see acre upon acre of magnificent indigo and sugar cane, while hardly a blade of any food-grain was to be seen. The same remarks apply, though in a very much less degree, to cotton.' Crop patterns in canal-irrigated areas persisted with their preponderance of 'valuable' crops, as did the consequent lack of any effective remedy for recurrent dry seasons. Again in 1880–1, an official report noted that 'highly cultivated crops (sugar, wheat) suffered as might be expected least damage while the drought was felt most by peas and gram and the other pulses . . . sown on inferior localities and out of reach of water'. The fact was that, except for crops sown before the onset of the monsoon proper, irrigation in the *kharif* was practically inconsiderable and, as was clearly stated by the highest officers of Government in the provinces, 'must always be more or less so'. When the rainfall failed entirely or almost entirely, canals and wells could not take its place.

Only in those few areas where canal irrigation combined with excellent soil conditions to make wheat the chief grain staple was the threat of scarcity least felt. As previously mentioned, the Jat proprietors of pargana Kotanah, Meerut district—a by-word for fertility—not only were saved by the East Jumna Canal during the drought and famine of 1860–1 but made enormous profits by supplying grain to stricken districts of the NWP famine tract. Generally speaking, canal irrigation did, and could do, little to decrease the ravages of scarcity by expanding the sources of staple food supply; indeed, its effect tended to be the reverse, to contract them—a process which tended to worsen with the added stimulus of the export trade in grains, particularly wheat, beginning in the late 1870s. In addition, the canals incited the cultivators to load the land with an unrelieved burden of crops year after year, disrupting the regular practices of fallowing. As we have seen, Colonel William Sleeman reported double-cropping and consequent deterioration of the land through exhaustion to be conspicuous in certain Doab districts at least by 1850. A sizeable area of *dofasli*, or double-cropped, land was generally taken by field officers as a sign of local prosperity. A. B. Patterson however agreed with Sleeman and drew attention to the dangers of gross deterioration from the obvious over-cropping in Fatehpur district, where, he warned, cultivation was increasing in area and intensity with a disregard for the necessary relief to the soil. He admitted further to hearing from 'men familiar with Oudh' that there the same distressing tendency was now evident also: 'the *pax Britannica* [as Patterson's report obligingly states] has worked its natural effect in inducing a dense population to keep as much land as possible constantly under cultivation, and . . . the 'Garden of India' has already lost some of its relative superiority in fertility.'

This tendency was encouraged by the canals. Auckland Colvin noticed it as early as 1864, in pargana Thana Bhawan in the canal tract of Muzaffarnagar district:

> . . . the chief danger in the canal area is overcropping. The land is rarely allowed to rest. For example, cotton is sown in a field in autumn, and wheat follows as the next crop; chari will be sown the following autumn, succeeded by wheat, then cotton as before and so on. The only crop for which the land is rested is sugar cane, and not for more than one season. In ordinary villages, this system is kept within bounds, not more than 10 per cent of the cultivated area 'do-fuslee' but on the canal, it is carried to excess. The cane is very much deteriorated.

According to Lieutenant-Colonel A. F. Corbett, whose *Climate and Resources of Upper India*, published in 1874, was the first outspoken technical criticism of the Government's zeal in promoting canal irrigation at all costs, over-cropping in itself was only a superficial explanation of the noticeable decline in productivity in certain canal tracts. A more fundamental cause could be found in the increase of irrigated area under the stimulus of the canals. By irrigation, as Corbett explained,

> . . . the whole surface-soil is brought into the condition of sun-dried bricks; the more water that has been applied to the land the harder the soil becomes, and while its powers of absorption and radiation are reduced, those of reflection and retention of heat are increased; and we find also that the power of capillary attraction possessed by the land is increased, and that the soil so compacted will sooner become dried up than soil left loose and open, partly from the fact of the interstices between its particles having been reduced in size, thus increasing its capillarity, and partly from the increased heat of the surface . . . .

This hardening of the upper soil by irrigation coincided with the consolidation of a '*pan*' in the sub-soil

> by the treading of cattle in ploughing . . . This causes shallower ploughing, the roots of plants have less depth of soil in which to search for food, and cannot force their way into the hardened pan; and there is the alternate soaking and drying of the land, during which the natural salts of the earth are gradually brought nearer the surface by capillary attraction.
> This process may go on for some years before the land shows any excessive amount of *reh* (saline efflorescence) on the surface; but the soil is steadily being poisoned by its accumulation in the upper soil, which accounts, together with the increased hardness of the soil, for the diminished fertility of lands some time under irrigation.

Why did this not happen with the large numbers of irrigation wells worked in the Doab districts? C. H. T. Crosthwaite explained the reason for the decline of canal—as against well-irrigated—land as follows:

> . . . wells require a large livestock and great labour. The soil reaps two benefits therefrom: more manure saved from burning, and the tendency to overfarm checked. If a farmer has to work his well, he cannot sow more sugar and wheat than he has time to irrigate but when he is relieved from all well duty he has nothing to keep him within bounds. He sows more of these crops, and has less manure . . . The extraordinary large produce of the first years of canal irrigation calls forth all the powers of the soil but if not backed up by a due supply of other food, it leaves exhaustion behind it.

Meanwhile the over-watered, unmanured soil was still ploughed up with bullock teams. Problems of double hardening inevitably followed, and an ominous increase in the barren and frequently *reh*-infected land known as *usar*.

Crosthwaite had reported with some alarm the spread of *reh* in pargana Phapphand, Etawah district—irrigated by the Ganges Canal—as early as 1871. Although *reh* was as yet by no means widespread, as G. H. M. Ricketts, then Officiating Commissioner of Agra Division, was at pains to point out when commenting on Crosthwaite's report, it was nonetheless an evil 'demanding an immediate remedy'. Seven years later, and two years after Corbett's careful examination of the *reh* problem, the condition had become far more obvious—sufficient now to cause serious, if somewhat academic, concern on the part of Government officers. A committee was appointed to investigate the problem thoroughly, on the basis of reports chiefly from a Mr David Roberts, a substantial zamindar of pargana Sikandra Rao, Aligarh district—of the disastrous spread of *reh* in parts of Aligarh, Meerut, and throughout the Kali Nadi valley. In each case some hundreds of acres, which in these populous districts represented thousands of livelihoods, had been put out of cultivation; in each case, the damage was directly attributable to excessive irrigation by canal water. In introducing the final report of the Reh Committee in 1878, Buck, then Director of Agriculture in the provinces, warned that these and similar cases noted elsewhere, brought to light at the last minute and even sometimes by accidental observation, were 'the first and earliest outcome of the introduction of a canal system' (it was now four years since the publication of Corbett's treatise), and that the same disturbing influences might be slowly at work in many areas.

The findings of the Reh Committee amounted, in substance, to little more than a corroboration of Corbett's assertions. Its enquiry was far from adequate. No account, for instance, was given of the extent of *usar* tracts in the provinces: they were said to cover 'immense areas', without details as to acreage. No agricultural chemist

was appointed to the committee nor even consulted during the investigations. However, the committee's final report made it clear that the chief cause of the increase in *usar* had not gone unnoticed: they condemned the 'vicious system' (in Buck's words) of swamping the fields for irrigation, which was the direct result of the accessibility of 'flush water'. The 'true remedy' was stated equally categorically: a greater economy in the distribution of water, to be achieved by the raising of rates charged by Government on flush irrigation. This was more than the Canal Department could provide. Since flush rates were already high, an increase would deter farmers altogether with disastrous results for the revenue accruing from canal charges. The committee itself realized that a remedy which it acknowledged to be inferior would have to be applied and recommended accordingly that lift irrigation should be substituted for flush irrigation as far as possible—'a waste of labour for a waste of water', sighed the president. He was encouraged solely by the realization that the waste of water was by far the more serious evil, leading as it so clearly had done to swamping, thence to deterioration of the soil and of the health of the people, thence to a diminution of their income, and ultimately, it was certain, to a reduction in the land revenue. For the rest, the committee recommended that experiments in reclaiming *usar* tracts which had begun in 1874 under the supervision of the newly created Department of Agriculture should be continued. These consistently showed that *usar* could be brought back into cultivation only by careful watering accompanied by intensive manuring. Nothing however was done on any significant scale to increase the local supply of manure near these tracts in order to keep pace with the increase in irrigation from the canal. When Dr J. A. Voelcker, the first agricultural chemist to be appointed by Government to report on Indian agrarian conditions, toured India in 1891, it is hardly surprising that he found 'enormous tracts, especially in the plains of Northern India', affected by *reh*. In the NWP alone, it was estimated to cover between 4,000 and 5,000 square miles. In the midst of this desolated *usar* land, patches of 'valuable' crops—opium, sugar cane, wheat, castor-oil plant, and cotton—stood out 'like oases in the salt-covered desert around them'.

The contrast between the benefits and drawbacks of canal irrigation was not always so clear to the eye. In Etawah, for example, the indices of prosperity in the form of extensive cultivation of 'valuable'

crops dominated the scene. The drought of 1868–9 had brought a stimulus to irrigation from the Ganges Canal. The falling-off in the use of the canal water after these dry months was however 'chiefly confined to cotton and ordinary kharif crops which would not benefit by irrigation', whilst the area under indigo began rapidly to increase, as did canal-irrigated sugar cane. The rest of the picture was filled in from the complaints of local farmers, recorded in this instance by Crosthwaite, when on settlement work in the district. They complained of corruption by the authorities administering the canal (standards seemed to vary with the character of the successive district canal officers). They complained of uncertainty in the supply of canal water and of its inferiority as a fertilizing agent. They complained, as might be expected, of the deposits of silt and *reh* and the consequent deterioration of the soil. Kachhis, the skilled gardener-cultivators, and even the officers of the Government Opium Department were reported to have a marked preference for wells. But the real disadvantage of the canal was, as 'universally asserted in Etawah that 'after the first two to three years, the crops do fall off'. Along with all this, the canal disrupted the farmer's former pattern of work. Far from firing him with the much-heralded spirit of industriousness which increase was assumed to bring, canal irrigation required less by way of labour than his well had demanded. As Crosthwaite went on to note,

> . . . the great relief from labour given by the canal probably goes as far as anything else with an ordinary peasant in directing his choice when it is possible for him to choose [between canal and well]. When a man has no sons or male relatives to help him, or when he has to keep more bullocks for irrigation than he wants for his plough, he may realize that he actually saves money by employing the canal. But ordinarily it strikes him the other way. The expenses of well-irrigation disbursed by degrees consists [sic] largely of the consumption of the cultivator's own produce. The canal rate has to be paid in cash, and in a lump sum, and by a stated time, its collection attended by all the annoyance of a tax. To the average cultivator the canal appears an expensive business more costly than his well, but . . . he is swayed by his being saved an infinity of toil, and his ability to irrigate a much larger area of land . . . .

It was not always a matter of choice for the farmer. He had to use canal water where the canal had put local wells out of use, especially where it had made well-digging impracticable by the rise in the water table which it had caused. Whiteway made enquiries as to the situation in Muttra in the hot weather of 1878—a difficult

season—and discovered that all *kachha* wells in villages through which the main (Agra) canal passed and from which more than 5,000 acres had previously been irrigated were now useless, owing to the rise in spring level. He concluded with caution that the canals therefore were, very possibly, a failure as an insurance against famine owing to their indirect effect on indigenous methods of cultivation. The Secretariat noted the following year that Whiteways' remarks were 'deserving of attention'.

Deleterious effects of canals on wells were by now widely noted. Saturation of the sub-soil was especially common in *bhur* irrigated by the canals, and this in turn caused the sides of *kachha* wells to fall in and made the continued construction of them to any depth out of the question. In Bulandshahr, according to R. G. Currie, a general rise of some six feet in the water level all over the canal area had resulted in the *kachha* wells being almost entirely superseded. A similar situation was reported from Mainpuri, and W. H. Moreland later collected further examples of this destruction of *kachha* wells in canal tracts from Aligarh and Agra. The only remedy was to construction a *pakka* well. Its cost in materials and labour, however, made it inconceivable as a viable alternative for the majority of farmers.

The problems that canals caused or, more often, aggravated were not restricted to over-cropping, salination, and the destruction of wells. Percolation from main channels or *rajabahas* (distributaries) could create swamps. In the Budh Ganga valley area of Etah district, the entire sugar cane crop of 1878–9 was ruined by this. The Canal Department provided the sum of Rs. 4,150 in compensation, but it did not undertake to drain the swamp. More widespread and serious swamping arose from the canals' obstruction of natural drainage lines where an insufficient number of syphons had been built to carry the canals beneath these natural watercourses. The obstruction caused by canal embankments led to swamping, the worst consequence of which was the aggravation of malaria. During the 1870s, the incidence of the disease increased alarmingly throughout the canal-irrigated districts where the saturation from flush irrigation coincided with the obstruction of natural drainage lines. In spite of a series of minor drainage operations begun by the Irrigation Department, fever continued to be a frequent cause of death and, worse still for a larger number of cultivators, a frequent cause of debilitaton, especially in districts with large irrigated areas.

According to Alan Cadell, even the climate in Muzaffarnagar had grown worse, in terms of an increasingly unhealthy humidity, 'than it was before irrigation from the canal became so general and the cultivation of rice [an export staple] so much extended'.

A farmer in a low-lying area irrigated by a canal might therefore have had to face a number of setbacks with which he was hardly equipped to deal. His fields might become salinized. If they lay close to an irrigating channel, he might have had the (often doubtful) benefit of easy access to the water supply or the prospect, alternatively, of swamping from drainage obstructions. Such drainage channels as were built to take excess water off the land ran into the same problem with the natural lines; a farmer might therefore oppose their construction, with reason. The obstruction or inadequacy of drainage facilities increased the dangers from seasonal flooding. Excessive rain in the early *kharif* would turn his irrigated fields into a lake and drown his 'valuable' crops. Meanwhile, his well might have fallen into disuse, leaving him no alternative but the canal for his irrigation. With the expansion of cultivation of 'valuable' crops into land formerly occupied in part by staple cereals and with the increase in population, his food supply became more precarious. Not only food, but fuel and fodder were also threatened: 'Since the introduction of canal-irrigation on an immense scale in this part of the country, the conditions of agriculture have been almost revolutionized,' William Crooke, then manager of the Awa estate in Etah district, declared in reviewing the situation in the Central Doab towards the end of 1881. 'A great part of the culturable waste lands had been broken up, and the supply of firewood and grass seriously diminished. The consequences would have been more serious had not the use of canal-water enabled the cultivators to dispense with a large number of their plough cattle.' This, however, as Crooke went on to show, was of little genuine assistance for the farmer in dealing with this sudden revolution in his environment, especially since his techniques remained unadapted to the changed circumstances. 'The number of cattle now maintained is, in comparison with the area under cultivation, inadequate. This has led to a slovenly system of cultivation, and has greatly reduced the manure supply.'

Early in the century, *dhak* jungle (*butea frondosa*, a fine timber tree which also provides excellent charcoal when burned) had covered much of the Doab. With the extension of agricultural settlement, the jungle had been largely stripped away, leaving bare *usar* patches

by the time when Crooke was writing. As a result, forage and fire-wood for the cultivator had already become scarce and costly—a condition which was now aggravated by the canals. Fire-wood, according to Crooke, cost a rupee for four *maunds*, assuming it could be bought, and dry grass for cattle was sold at from two to four *maunds* a rupee. The condition of cattle, especially during the thin period prior to the rains when no fresh fodder was available, was 'miserable in the extreme'. Cattle starvation and concomitant diseases (rinderpest, foot-and-mouth disease, fever) became regular ocurrences which were aggravated by, rather than originating in, years of severe drought.

Could this be remedied? Crooke himself advocated a scheme which would combine the reclamation of *usar* tracts in the Central Doab with the establishment of fuel and fodder reserves. Exhaustive discussions over the next three years by the Revenue Department, however, revealed the 'material difficulties' which prevented the implementation of this project and other proposals to buy up waste land and enclose it for emergency reserves: the cost was too great for Government. These same schemes went forward for discussion by the Revenue and Agricultural Department of the Government of India, and were wrecked on the same rocks:

> The expense of taking up as reserves even a small proportion of waste lands now used as pastures would be enormous. For example, a reserve of some 6% of the grazing grounds of Bareilly would cost for acquisition alone Rs 1 1/2 lakhs [Rs 150,000]. The experiment of acquiring and enclosing 954 acres of usar land in Aligarh is to cost Government more than Rs 10,000. Without multiplying illustrations, it may be briefly said that in those fully settled districts, where pressure on the available pasturage is felt, no reserves could, by fencing, planting, and re-foresting waste and *usar* land, be created which would have an appreciable effect, except at an outlay so enormous as to place the measure at present beyond the means of the Government to undertake . . . a small experiment in reclaiming and planting *usar* has been in progress in Cawnpore since 1882. The results so far demonstrate the necessity of great caution in undertaking any large expenditure on the formation of grass preserves in such soil . . . .

Meanwhile, the contraction of fodder areas in the Doab had a direct effect on the pastoralists who supplied cattle to the agricultural communities. In pargana Lonee, Meerut district, the expansion of cultivation was rapidly converting the traditionally pastoral Gujars into settled agriculturists, a transformation described by the Settlement Officer, Forbes, as in the 'spirit of industry'. The

same transformation was taking place in pargana Dadri, Bulandshahr district, where the Gujars, according to the Settlement Officer, had begun to 'recognize the value of property': they 'have benefited considerably', Currie wrote, 'by greatly increasing their cotton cultivation in the last two years'. But here too there were problems. Most Gujar settlements were situated in the low-lying *khadir* areas—the river valleys—where the constant threat of inundation meant little regular *kharif* cultivation could be hazarded, whilst pasture lands were extensive, with long grass flourishing in the moist soil conditions. Gujars therefore derived their regular livelihood from grazing and from the sale of thatching grass, and their food supply from *rabi* grains since these were sown when there was no threat of flood. When conditions prevented cultivation, they could resort to cattle thieving. Thus, with the expansion of cultivation into the *khadir*, the Gujars benefited from rabi cultivation, though the *kharif* crops were still precarious. But with the conversion of the Gujars into agriculturists, the supply of cattle to the cultivators necessarily contracted; for this reason, cultivators had to rely on their own, often deteriorating, stock. Meanwhile, Gujars in areas outside the range of the canal developments remained obstinately unmoved by the 'spirit of industry'. In Muzaffarnagar, Auckland Colvin noted in 1864 how the Gujars of pargana Bedauli derived their chief support from cattle. 'This', he wrote, 'supplies them with a motive for maintaining large tracts of uncultivated land, and materially diminishes their necessity for cultivating land'. It was assumed that this regrettable situation could be changed only by the realization of enormous gains from an increase in cultivation. 'Nothing, I believe, will outweigh this motive but some agent not only bringing greater profits than cattle-stealing and cattle-breeding, but profits sufficiently great to supplant the old pleasant habits of indolence and theft by the laborious habits of toil and agriculture.' Such an agent was to be found in Colvin's view in the form of canal water. Crosthwaite's observations on the labour saving consequences of the canal lead one to doubt a priori that Colvin's vision would ever be realized. . . .