

APPENDIX.

Growth of irrigation from the Western Jamna Canal, and extension of saline efflorescence and swamp.

The figures below show the irrigation from the *whole* of the Western Jamna Canal, from 1819 to 1840, no separate figures being available for the district. The Dehli branch was opened in 1820, but the small supply of water carried by it may be estimated from the fact that till 1826, *at least*, no bridges were needed, as a loaded village cart could be driven through it without inconvenience. In 1826 the Rohtak branch was opened as far as Gohána; but the irrigation from both these canals, though steadily increasing up to 1833, was still very limited, and in 1831 the small use made of the water was attributed to "the uncertainty of the supply, the insufficiency of the outlets permitted for each village, and the high rates "charged" viz., As. 11-2 per acre.

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Early Irrigation from Western Jamna Canal.

Year.	Amount of water-rate in rupees.	Area calculated at average rate of As. 11-2 per acre.	REMARKS.
1819-20 ...	876	1,255	Main line & Dehli branch opened.
1820-21 ...	14,646	20,988	
1821-22 ...	24,619	35,279	
1822-23 ...	21,458	30,749	
1823-24 ...	36,015	51,609	Drought.
1824-25 ...	26,647	38,185	} Famine.
1825-26 ...	48,374	69,320	
1826-27 ...	33,975	48,686	Rohtak branch opened.
1827-28 ...	34,161	48,953	
1828-29 ...	52,953	75,882	
1829-30 ...	53,375	76,486	
1830-31 ...	57,700	82,604	
1831-32 ...	51,016	73,106	
1832-33 ...	65,805	94,299	
1833-34 ...	1,48,783	2,13,206	Famine.
1834-35 ...	1,14,065	1,63,455	
1835-36 ...	1,10,603	1,58,494	
1836-37 ...	1,53,177	2,19,503	
1837-38 ...	2,72,378	3,90,318	Drought.
1838-39 ...	1,89,645	2,71,761	
1839-40 ...	2,24,383	3,21,541	Rain scanty.
1840-41 ...	2,55,818	3,66,587	Contract system introduced.
1841-42 ...	2,63,069	3,76,978	
1842-43 ...	2,79,300	4,00,237	

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The terrible famine of 1833-34 gave a new turn to the irrigation question. This famine fell with perhaps even greater severity upon the Bángar than upon the Khádar; for the canal failed, while the people of the latter had at least their wells, so long as the cattle had strength to work them. The distress, feebly described at page 23, paralysed for a whole year the agriculture of the tract. But this very distress was the means of securing at one bound an advance in prosperity which might otherwise have taken many years to attain. The canal presented at least a possibility of salvation; and its officers had no longer reason to complain that the water they proffered was not accepted. Irrigating villages enlarged and multiplied their channels; numerous other villages which had never before irrigated dug cuts for themselves, often many miles in length; and the area irrigated was limited only by the means of supply, instead of, as heretofore, by the demand. Strenuous efforts were made to increase that supply; and the irrigation of 1833-34 was $2\frac{1}{4}$ times that of 1832-33, while the construction of the Butána branch extended the water to a part of the tract which it had previously been unable to reach. The means of irrigation, once called into existence by the pressure of a water-famine, were still available when the urgent necessity had passed away; and the irrigation never again fell to its former level. The failure of the rains in 1836-37 raised it above the figures of 1832-33, and the continuance of the drought caused the irrigation in 1837-38 to rise to what Captain Baker, the Superintendent of Canals, declared in 1841 to be the maximum capacity of the channels as they then stood. But the supply was still uncertain, and apt to fail when most needed. The whole system of canals and their subsidiary channels had been called on to perform a task far in excess of that for which they had been designed; the call had been urgent, and the necessary adaptations had been made as best they could, and on the spur of the moment. The arrangements at the heads for supplying the water from the river were also very imperfect; and too often the canal broke down just when there was the greatest need for its services.

Year.	Acres.
1876	60,744
1877	85,172
1873	123,567
1879	97,334
1880	77,027
1881	62,380
1882	69,483
1883	87,035

The table on the opposite page shows the irrigation between 1865 and 1875. The figures refer only to the portion of the district settled by Mr. Ibbetson; but the canal irrigation excluded is insignificant in amount. Since that date the area charged with water-rate in the Karnál District has been as shown in the margin.

When the canal was re-opened, every facility was offered to such villages as would make use of the water. In most cases an old imperial water-cut still existed, which they were allowed to clear out and use; and when there was none, they simply made themselves a channel straight from the nearest point on the canal from which water would flow to their fields. As the demand for water has extended, certain large distributaries have been constructed, which have absorbed many of the early channels, while others have been deepened, enlarged and extended. The main canals, too, have been deepened and their banks

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Year.	KARNAL BANGAR.		PANIPAT BANGAR.		Cotton.	Sugar-cane.	Rice.	Wheat.	Gram.	Barley.	Barley and Gram.	Miscellaneous and fodder.	Patoe and <i>saltabi</i> .	Total area.
	Canal areas.	...	Canal areas.	...										
1865	1,393	533	7,455	651	6,257	674	993	46	756	4,045	22,830			
1866	2,192	180	7,652	456	8,964	784	371	1,657	1,015	5,769	27,333			
1867	1,812	98	6,003	16	6,489	448	362	1,436	509	1,642	18,211			
1868	2,518	320	6,788	2,240	13,052	606	2,723	677	2,590	1,360	33,081			
1869	3,016	665	9,163	1,334	9,063	570	2,232	825	1,539	2,236	30,904			
1870	3,786	315	9,097	231	9,080	645	2,492	1,226	1,519	987	30,776			
1871	1,633	179	6,621	82	9,841	1,001	1,623	276	1,872	792	24,004			
1872	2,982	543	5,531	108	6,970	302	416	724	983	4,000	21,780			
1873	1,123	492	7,145	74	5,453	159	619	274	963	4,638	20,983			
1874	...	...	...	...	...	...	...	...	...	...	20,823
1875	...	...	...	...	...	...	...	...	...	...	19,368
Average ...	2,273	370	7,278	577	8,241	610	1,308	795	1,416	2,541	24,555			
1865	7,899	4,206	10,449	4,658	22,217	1,201	494	4,714	2,099	5,446	63,473			
1866	12,171	2,048	12,390	1,450	28,373	921	439	4,254	3,495	6,154	71,916			
1867	11,467	2,853	8,325	448	20,339	1,531	436	3,118	2,893	1,757	53,174			
1868	9,441	5,185	7,367	7,796	36,339	2,021	2,665	2,256	6,587	948	80,683			
1869	11,121	7,120	8,048	7,773	27,534	2,563	1,726	3,166	6,148	1,842	77,431			
1870	13,296	5,564	8,768	2,175	26,653	1,902	1,746	2,263	6,253	1,273	70,023			
1871	12,474	4,322	7,225	666	26,413	1,636	1,682	3,768	6,096	808	65,450			
1872	9,519	5,234	9,390	388	11,028	853	488	1,869	4,044	4,512	47,449			
1873	4,790	5,355	8,651	466	9,024	224	407	811	4,407	5,177	39,378			
1874	...	...	...	...	...	...	...	...	...	...	48,189
1875	41,669			
Average ...	10,242	4,665	8,957	2,869	23,224	1,373	1,121	2,913	4,669	3,108	59,894			

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raised, till the water touches the crown of the arches in the bridges. Most of these extensions were made under pressure of urgent need, and therefore without interrupting the supply, and too hurriedly to admit of due consideration being given to them, or of the best possible scheme being selected. Thus, while the faulty alignment of the old canal and channels is still followed, their carrying capacity has been so increased that in most part the surface level of the water, and in some places the bed of the canal, is above the surrounding country, and the water is thus forced into the sub-soil by hydraulic pressure.* A great deal of the canal is, of course, in embankment; and in many of the secondary channels silt clearances, often dating from the time of the Mughals, have raised the banks to a height of 12 and 15 feet; and this system of embankments has been constructed with so little reference to the natural drainage that it intersects all the drainage lines of the tract, and throws back the surface water over the surrounding country. This is especially the case in Karnal Bángar, where the canal runs in embankment below the Nardak step in the Bángar, and the Khádar bank in the Khádar, and holds up all the drainage which runs southwards from the highlands. The highland distributaries which cross the lowland to reach the villages on the crown of the slopes, act as so many dams above which huge swamps form, while the poops of the old channel in which the canal used to run, and which are cut off by it now that it has been straightened, act as breeding beds for crocodiles and malaria.

Excessive irrigation practised by the people.

But if the defects of the means of supply have given rise to evils, the pernicious system of irrigation pursued by the people, coupled with its rapid extension has increased those evils a hundred fold. While some 8 per cent. of the central canal tract is permanently under water, 40 per cent. of the whole area and 80 per cent. of the cultivated area is irrigated much of it twice in the year, much of it for rice cultivation, and almost all of it every year without intermission. New canal irrigation is not like well irrigation. When every drop of water used is represented by additional labour to man and beast, the greatest economy is exercised; not so when a stroke of the spade is sufficient to set flowing an unlimited supply. In the former case the cultivator divides his fields into small beds which are irrigated successively, and practically answer the purpose of terraces economising the water, not only by reducing the depth needed, but also by confining the area of already watered ground over which the water has to pass. On the other hand, if a field is six inches lower at one end than at the other, a seven-inch bank is

* The total irrigation from Western Jamna Canal at various periods in shown below :—		The average depths of water in feet at Karnál bridge at various periods is as follows :—	
Years.	Acres.	Years.	Feet.
1820	155	1827	4.81
1825	38,185	1830	5.20
1830	76,486	1835	6.93
1840	321,541	1870	9.81
1870	496,542	1875	10.10
1878	507,974		

And the bottom from which these depths are measured has been raised considerably during the period over which these figures extend.

made round it, and the whole field put under an average of four inches of water, in order to get one inch at the top; each spot in the field, after receiving its water, is still passed over by the water which goes to spots beyond it; and if a leak occurs in the channel, or if a bullock breaks down the side, the water is allowed to run to waste for hours before any trouble is taken to remedy the evil. The duty of the canal water for 1874-75 was 74 acres in the autumn, and 89 in the spring per cubic foot of supply. Supposing that the loss by evaporation and waste is counterbalanced by the fact that much of this land is watered in both seasons, this represents a supply of 62 inches in the year. A well working 13 hours a day for 150 days in the spring and 80 days in the autumn, and watering 15 acres, would have to supply at this rate 6,067 gallons per hour. Moreover, the well water is itself drawn from the subsoil supply, and all that is lost by evaporation during the process of irrigation is so much lost to that supply; while in canal irrigation, all that is *not* so lost, is so much *added* to that supply.

The result is that the whole country is water-logged by the canal water being forced into it from below, while the cultivator drenches it from above. And when the rain comes in tropical abundance, instead of finding a thirsty soil ready to drink up the greater part, it falls upon a country already saturated with water. And the whole volume is thrown into shallow drainage lines with an almost imperceptible slope. These again, being barred at intervals by high banks crossing them at right angles, silt up, and the water is thrown back and covers the country for miles. Thus, when the rainfall has been unusually heavy for several years in succession, there are hundreds of acres in which the autumn crop, if it can be sown at all, is almost or altogether drowned; while such little land as appears above the water soon enough to plough for the spring crop is so moist that the yield is barely worth the trouble of gathering. And there is a still larger area in which, after heavy rain, the water stands some inches deep for three or four days at a time, to the great injury of the crop. No means exist of carrying off the water, for, as the Chief Engineer reported in 1867, "the level of the water in the canal can very seldom be reduced in the rainy season, just when the drainage of the swamps is most needed; as even if the supply at the heads be shut off, the quantity of water draining into the channel above Karnal is sufficient and sometimes more than sufficient, to fill the channel at and below, that point."

Nor is it only swampage that results from the causes above mentioned; for if it were the higher land might be cultivated as the lower became unculturable. For countless ages the rain falling upon the soil has washed down with it more or less of its saline constituents into the spring water below. That water now has been raised to within such a short distance of the surface that it can rise to it by capillary attraction, carrying with it salts which have been thus accumulated. As fast as it reaches the surface, wherever the cultivation or the shade of a thick tree does not interfere with radiation and evaporation, the fierce heat of an Indian sun concentrates the solution. Where the water is so near the surface, and the surface moisture so great that diffusion can take place, and the water thus made heavier can return

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Resulting swamps.

Resulting saline efflorescence.

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Resulting saline efflorescence.

by the way it came, no great harm is done. But over most of the area this is not the case, and the water evaporating leaves the salt deposited; and this process, repeated year after year, eventually covers the soil with a flocculent layer of alkaline salts, lying like fresh-fallen snow, often three or four inches thick. The first rain that falls is not heavy enough to reach the main drainages, and sinking in *in situ* carries with it the salts; thus preserving them by a sort of occlusion from the mechanical action of heavy rain, to reappear when the next sunny day restores the process of evaporation.*

The salts lie thick round the edges of the cultivation, and, notwithstanding the bank made to keep them out, are carried over the boundary by the wind and rain and deposited in the hollows of the out-lying fields. When once cultivation is thus destroyed, the capillary process immediately begins, and thus the evil is gradually eating its way from outside into the still fertile fields, every inch gained being made the stepping-stone for further inroads. The saline water and such grass as is able to spring up in the salt-impregnated land give the cattle diarrhoea and glandular affections, enfeeble, and eventually kill them; while the large area which is each year covered with water and aquatic plants in the rainy season, and dried up by the sun during the remainder of the year, exhales from its putrefying vegetation a malaria which poisons the blood of the villagers, renders them impotent, and kills them by fever and spleen disease.

Effects upon health and prosperity.

The epidemic of 1841-43, which assumed especial virulence in the canal tract, and caused the abandonment of Karnál as a cantonment, led to the appointment of a Committee by the Supreme Government to investigate the matter. Their report was published at Agrá in 1847. In 1867 Surgeon-Major Adam Taylor was appointed to make a further inquiry; and his report was published as Selection No. VI of 1870 from Records of Government Panjáb. Some of the figures of both reports are summarised on the opposite page.

Dr. Taylor shows that 60 to 80 per cent. of the inhabitants in *many* of the Bángar villages were suffering from enlarged spleen and yearly attacks of fever. He speaks of the "languor and depression" of manner, and stunted and shrivelled forms of the inhabitants of "the villages in close proximity" to the swamps; and of the absence of "the strength to repair damages or to preserve comfort." The heavy rains of 1871-76 rendered the sanitary condition of the canal villages worse than ever.

In 1856 the people of many of the worst villages abandoned their homes and fled to Jínd; and Mr. Sherer was deputed to inspect the tract. His admirable report was submitted in 1857, and is printed as part of Selections No. XLII (1864) from Government of India correspondence, P. W. D., pages 4-15. He showed that the water-level had been raised by the canal from some 60 feet to, in many places, two or three feet from the surface; that the fertility of the soil had been very generally diminished; and that the evil had

* An immense amount of information and discussion on the subject of *reh*, its origin, formation, effects and cure, will be found in the report of the Aligarh Reh Committee of 1878, in Selections No. XLII (1864) from Government of India correspondence, P. W. D., and in the printed correspondence with Board of Revenue, N. W. P., No. 231 of 21st October 1874, and Government, N. W. P., Revenue Department, Index Nos. 61-83 of May 1877.

Statistics of Disease on Western Jamna Canal.

Locality.	Distance from Canal.	Depth of water below surface.	Percentage of large spleens.	PERCENTAGE SUFFERING FROM FEVER IN		
				1844.	1845.	1864.
REPORT OF 1847.						
WESTERN JAMNA CANAL.						
Dehli Branch ...	Within half a mile ...	11	58	51	45	41
	More than a mile ...	18	49	51	49	40
Rohtak Branch ...	Within half a mile ...	28	44	47	38	27
	More than a mile ...	48	29	34	34	27
Butána Branch ...	More than half a mile	102	16	41	36	22
NON-CANAL VILLAGES.						
Dehli territory ...	...	88	11	32	28	11
High Doab ...	...	24	8	37	31	20
REPORT OF 1867.						
Dehli Branch ...	Within half a mile ...	6	61	33	20	63
	More than a mile ...	11	44	40	38	66
Rohtak Branch ...	within half a mile ...	5	41	36	36	51
	More than a mile ...	7	47	44	54	68
Butána Branch ...	More than half a mile,	45	7	33	28	32
Between the canals...	...	8	47	34	41	65

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not nearly reached its limits, but must necessarily continue to spread almost indefinitely.

From a sanitary point of view he found a state of things existing "very much worse than that described by the Committee of 1847." He speaks of the miserable disease engendered by the tainted water and malarious exhalations of the soil; of the spectacle of sick women and diseased children crouching among the ruins of their houses (for in many cases the rafters had been sold), of haggard cultivators wading in the swamps, and watching their sickly crops, or attempting to pasture their bony cattle on the unwholesome grass.

In the beginning of 1877 Mr. Ibbetson, reporting on the assessment of the canal tract, wrote as follows:—

"The villages of the tract may be described under three heads. Those which, well removed above the influence of the *reh*, reap the benefits of the canal without being subject to its injuries, are eminently prosperous.

"Those villages, which, though out of the lines of drainage and swamp, are so low that their pastures are covered by *reh*, are far less prosperous. Their cultivation has decreased, and must decrease still further; the fertility of what remains has diminished; expansion is impossible; what little grass there is for the cattle weakens and kills them, and the water is bad for both man and beast. Where the village is large and well off, they have saved the mass of their cultivation from any very great deterioration, and the inroads of *reh* are chiefly confined to the edges. But where the community is poor, the whole cultivation has suffered, and the *reh* advances with

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accelerating impetus. It is, then, most important to assess lightly this class of villages, so that they may not be hampered in their struggle with the evil.

"As for the villages which lie in the drainage lines, or have low land near the canal, their state is pitiful indeed. Their early cultivation was, as is the case throughout the district, in the lowest parts of their area; and while the higher lands were becoming covered with *reh*, the stiff soil of the fields helped to preserve the lower from injury. But as the water-level rose, and swamps and soakage began to extend, they found their cultivation under water, while, turning too late to their high lands, they perceived that they had become barren; and now they live a semi-amphibious life, their houses crumbling with the damp, crocodiles in their village ponds, the water in the wells so near that, as they say, they can 'draw water without a string,' their sickly feeble cattle obliged to leave the village during the rains, and they themselves suffering from all complications of malarious disease with an unbroken regularity. Year by year they sow rice with the certainty that only an exceptionally dry season can save it from being drowned, and that much of it must even then be injured by too much water; year by year they watch the fields as they dry up, and rapidly passing a plough through the tenacious mud, sow their wheat and barley in the open furrows till the very last moment when there is hope of their germinating, or even sow the seed on the unbroken mud, and plough over it when the ground is a little drier; and this in the knowledge that some of it will fail, that heavy rain will drown more of it, and that most of what does come up will barely repay the labour spent on it. Much of their land is sour and cold from being so permanently saturated with water that, though not under water, it cannot be cultivated; some of it perhaps is separated from their village by the canal, the nearest bridge being some miles off, and it being forbidden to take cattle to it along the bank. In a year of drought these villages no doubt reap splendid crops, but years of drought are fortunately the exception, and I think that the very largest allowance should be made for the circumstances of estates so situated.

"My experience of the tract was then limited to a probably exceptional series of seasons of full or excessive rainfall. Since then I have seen them during a series of, I hope, exceptionally scanty rain, and I think I exaggerated the *average* condition of the swampy villages. It would be difficult to exaggerate it as it is in really wet years."

General Strachey did not speak one whit too strongly, when he said in 1867:—

"The portion of the canal near Karnál is a disgrace to our administration, and has been for years past. It creates most pestilential swamps which must be got rid of, unless we are content to perpetuate this abominable nuisance, which has been talked about for the last 25 years, during which period no serious attempt has been made to abate it. For my own part, I distinctly reject all share in any counsel which tends to delay in meeting this most crying evil. I most fully admit the great importance of doing what has to be done with the most scrupulous regard to economy, and I am ready to sacrifice all thought of elegance or congruity for the purpose of avoiding any considerable outlay, which is really not needed to secure efficiency. But it is impossible for me to affirm, with too great positiveness, the moral obligation which rests on our Government to put an end, with all possible speed, to the discreditable condition of the large tracts of land along the Western Jamna Canal, which are converted into swamps of the most pestilential nature, not

only destructive to the health and life of the population, but occupying in a manner far worse than useless some of what might be the very best lands. It will be necessary to do something, and what is necessary should not be delayed till other works, which have no relation to this part of the scheme, are completed."

The new canal is now nearly complete; the re-alignment of the distributaries has already done much good, and the completion of the drainage scheme will doubtless go far to cure the evil of swamps. But the efflorescence will not be so easily got rid of; and it will, probably be many years before this scourge is very materially decreased.

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STATISTICAL TABLES

GAZETTEER

KARNAL DISTRICT

The following table shows the results of the
 experiments conducted on the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22nd, 23rd, 24th, 25th, 26th, 27th, 28th, 29th, 30th, 31st, and 32nd of the month.

No.	Date	Time	Result
1	1st	10:00	...
2	2nd	10:00	...
3	3rd	10:00	...
4	4th	10:00	...
5	5th	10:00	...
6	6th	10:00	...
7	7th	10:00	...
8	8th	10:00	...
9	9th	10:00	...
10	10th	10:00	...
11	11th	10:00	...
12	12th	10:00	...
13	13th	10:00	...
14	14th	10:00	...
15	15th	10:00	...
16	16th	10:00	...
17	17th	10:00	...
18	18th	10:00	...
19	19th	10:00	...
20	20th	10:00	...
21	21st	10:00	...
22	22nd	10:00	...
23	23rd	10:00	...
24	24th	10:00	...
25	25th	10:00	...
26	26th	10:00	...
27	27th	10:00	...
28	28th	10:00	...
29	29th	10:00	...
30	30th	10:00	...
31	31st	10:00	...
32	1st	10:00	...