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### Irrigation, natural and artificial, in Samarkand and Bokhara

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some incidents of those events which make us feel that those coalitions must have been somewhat unpleasant in their nature. Lord Beaconsfield once said that England did not love coalitions, and I am sure that there is no coalition that England would love less than a coalition of the kind described by Sir William Hunter on the frontiers of India. I had the privilege of travelling along the North-West Frontier, and of course it is impertinent for a civilian to speak about such matters, but it did seem as if by great outlay and by consummate skill we had made that frontier so impregnable that we need not dread coalition or conquest. And, ladies and gentlemen, I believe that there is a second barrier not less important than the mountain barrier which we have fortified in the north-west. I believe it lies in the contented populations of India. I am not quite sure that I understood what Sir William Hunter's view was of those populations. He said that the view at the present lay something between the former view and the future view of the nationalities of India. Well, I take it that even now India is populated by nations and creeds so diverse, so different, with limits so sharply fixed, that we cannot in any possible future, in any limited future, look forward to their becoming a homogeneous population. But we can at least effect this—to keep the scales of justice equally between those nationalities and those faiths throughout that mighty continent, which by that accident which after all is only the finger of Providence in history has been intrusted to our charge—to administer that great inheritance impartially, and to raise before any possible invader a second frontier of a contented and intelligent people.

The proceedings then concluded.

## IRRIGATION, NATURAL AND ARTIFICIAL, IN SAMARKAND AND BOKHARA.

BY VICTOR DINGELSTEDT.

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PUBLIC attention is largely directed just now to the vast and fertile regions of Central Asia. The Russians are endeavouring to reclaim for civilization those ancient historical countries which once were renowned in many branches of useful activity, and which, notwithstanding centuries of decline and many adventitious circumstances, still present a hopeful disposition. The prospect of these praiseworthy efforts to recall into new life the effete Oriental civilization will largely depend, in Central Asia, upon the solution of the physical questions regarding the distribution or *régime* of water-courses. The steppes and valleys in these rainless regions can be made habitable and productive only by the means of sweet water available in abundance, either through natural or artificial *media*. The art of irrigation and drainage thus assumes a position of the most vital importance. The most fertile and best situated part of Central Asia must be doomed to misery and stagnation, as long as there is no canal, which can bring in water for irrigation and drain off the surplus. The first part of the question—that of bringing in the necessary water—is generally easier of solution than the second,—that of leading it off,—

where, as in the marshes of Syr-Daria, it is too abundant. Our attention is therefore first claimed by those parts of Central Asia where there are many water-courses, having a sufficient fall to ensure the distribution of the water and to prevent its stagnation. The countries of Central Asia which deserve, from this point of view, the greatest attention, and to which is undoubtedly promised the best future, are the valley of the Upper Syr-Daria, called Naryn, and the valley of Zerafshan. The former, which comprises the greater part of Fergana ("blooming" Fergana—formerly Khokand) lies between  $39^{\circ}$  and  $43^{\circ}$  north latitude, between Semiretchinsk, from which it is separated by the Terskeala-tau and Sussam on the north, and the valley of Zerafshan, from which it is separated by the Kashgar-dag and Alai-dag on the south. The valley of Zerafshan contains the province of Samarkand and the semi-independent khanate of Bokhara. Zerafshan is just the kind of river that is needed for irrigation, and if its waters could reach the Amu-Daria it would be the most important affluent of the latter. Starting from the south-western part of Fergana, the oasis of Zerafshan, a name which signifies in Persian "gold-river," stretches in a westerly direction to the lake Dengehiz, 20 miles from the Amu-Daria, in about  $63^{\circ}$  E. longitude. In this paper I shall present to the reader of the *Magazine* some recent data about the discharge of rivers and canals in these cultivated regions of Central Asia; they are gathered from Russian semi-official sources,<sup>1</sup> and, in view of the peculiar character of the countries just mentioned, may be of some interest.

It might be thought that, in consideration of their striking importance, the rivers and canals of Central Asia would often be the object of study. But such is not the case: few investigations have been made, and what is most extraordinary, even the quantity of the supply of what is here the principal source of all riches has remained till quite recently almost unknown.

FERGANA.—A few words about the extent and character of the country before we turn our attention to the principal object of interest. The area of Fergana is estimated at 28,000 square miles, or 17,920,000 acres. The area of lands capable of cultivation is taken to be 2,188,115 acres, or 13 per cent. of the whole; 986,136 acres were actually cultivated in 1885, or 45 per cent. of the available area. The distribution of the different crops on these lands is as follows:—

|                                      |   |   |                |
|--------------------------------------|---|---|----------------|
| Cereals (mostly rice),               | . | . | 386,913 acres. |
| Djugarras ( <i>Holcus sorghum</i> ), | . | . | 204,833 "      |
| Lucerne,                             | . | . | 148,975 "      |
| Cotton,                              | . | . | 140,827 "      |
| Vines,                               | . | . | 44,434 "       |
| Fruit,                               | . | . | 36,785 "       |
| Oil-seeds,                           | . | . | 23,369 "       |

The area of forests is estimated at about one million acres (970,424), or about 6 per cent. of the whole territory. Fir trees occupy 282,085

<sup>1</sup> *Turkestaniskia Vedomosti*, 1887, Nos. 35 and 44; 1888, Nos. 5, 6, 13, 14, 15. Middendorf, *Ocherki Fergany*, S. Petersburg, 1887.

acres, or about 29 per cent., of the wooded area, after which the most largely represented species are walnut, pistachio, and a large variety of fruit-trees. It is a mountainous country; on the right or northern side of the Upper Syr-Daria (Naryn) there are the Alexander, Talas, and Chotkal mountain chains, on the left or southern side stretch the mountains of Kashgar and Alai. The woods occur at a higher altitude on the southern side of Naryn: namely, as high as 10,000 feet, and they are composed chiefly of fir trees; on the northern side the woods are not found at a higher altitude than 5000 to 6000 feet, and are mostly composed of foliage trees. The country is rich in coal mines, which have not, however, been examined at present. The number of inhabitants is estimated at 676,000 souls, out of which 538,800, or about 80 per cent., have fixed places of abode, and 137,200, or 20 per cent., are nomads. The Tajiks, representatives of the former class, are good agriculturists; the Usbegs, forming the majority of the latter, have been shepherds from time immemorial, and still remain averse to agricultural pursuits.

After these preliminary remarks, we may turn our attention to the water-courses—natural and artificial—that intersect the region of the Upper Syr-Daria. These water-courses are more numerous than might be inferred from the extent of the cultivated area, as shown by the numbers quoted above, and it is not the absence of rivers, but the mismanagement of them, and the lack of skill in utilising them, that confines this area within its present bounds. According to the measurements of Mr. Alexander Dmochowsky, executed by order of the Russian Government, the rivers of Fergana, the enumeration of which will follow, carry down on an average about  $63\frac{1}{2}$  thousand cubic feet per second. Such a supply of water, rightly distributed by means of a well-devised system of canals, would be considered in Italy as sufficient for the irrigation of  $5\frac{1}{2}$  million acres, or almost six times the area it fertilises in Fergana. The principal river here is, of course, the Naryn, as the Upper Syr-Daria is called from its sources to its confluence with the Kara-Daria. The Naryn takes its rise in Jitim-tau, in the mountains of Terskes-ala-tau, at 3786 feet above the level of the sea. It flows in a westerly direction, and down to its junction with the Kara-Daria near the plain of Namangan, which it reaches after forcing a passage through the Sussamir mountains, preserves the character of a mountain stream. It is navigable for rafts laden with fruit, hides, felts, etc. Formerly it was the Kara-Daria that was considered as the true source of the Syr-Daria, but this was a mistake, for the course of the Naryn down to the point of junction is almost double the length of that of the Kara-Daria, and the discharge three times as considerable. All the rivers in Fergana are tributaries of the Naryn and Kara-Daria, and take their rise in the mountains that border this province on the north and south. There are thirteen of these rivers, each of which has a mean annual discharge of over 1600 cubic feet per second, and twenty-six others, each with a discharge of more than 100 cubic feet per second. The list of these rivers is given below, as well as their present mean annual discharge per second, as determined by Mr. Dmochowsky, who has been gauging the rivers and canals of Fergana by order of the Government, during six years, at every season, and has

recently published the results of his labours in the official organ of the Governor-General of Turkestan.<sup>1</sup>

THE RIVERS OF FERANA AND THEIR MEAN DISCHARGE IN  
CUBIC FEET PER SECOND.

(1.) *The District of Osh.* Altitude of the town of Osh, 3559 feet.

The springs in this district give a mean supply of water of about 946 cubic feet per second. The principal canal—Aryk-Savaj—has a discharge of 105 cubic feet.

| Rivers—              | Cub. ft.<br>per sec. | Torrents—          | Cub. ft.<br>per sec. |
|----------------------|----------------------|--------------------|----------------------|
| Tchili, . . . .      | 2244                 | Tchashma, . . . .  | 265                  |
| Kirghis-ata, . . . . | 2424                 | Air-tash, . . . .  | 185                  |
| Akbûra,* . . . .     | 2695                 | Kokh-djan, . . . . | 288                  |
| Torrents—            |                      | Taldyk, . . . .    | 355                  |
| Kapka, . . . .       | 250                  |                    |                      |

\* Affluent of Kara-Daria.

(2.) *The District of Andijan.* Altitude of the town of Andijan, 1813 feet.

The springs in this district give a mean supply of about 653 cubic feet per second. There are seventeen canals, with a total discharge of 8718 cubic feet per second. The most important are:—Shaarkhan, 1585 cubic feet per second; Andijan, 1440; Mussulman-Kul, 1245.

| Rivers—               | Cub. ft.<br>per sec. | Torrents—               | Cub. ft.<br>per sec. |
|-----------------------|----------------------|-------------------------|----------------------|
| Jassy,* . . . .       | 2080                 | Ungur, . . . .          | 1580                 |
| Kara-Kuldja,* . . . . | 2145                 | Kugart, . . . .         | 1280                 |
| Tar,* . . . .         | 2235                 | Tchanget, . . . .       | 526                  |
| Kurshab, . . . .      | 1945                 | Isky-Massy, . . . .     | 128                  |
| Torrents—             |                      | Shaidin, . . . .        | 100                  |
| Maily-sai, . . . .    | 1085                 | Tash-ptchak, . . . .    | 108                  |
|                       |                      | Kara-taryk-sai, . . . . | 595                  |

\* Affluents of Kara-Daria.

(3.) *The District of Marghelan.* Altitude of the town of Marghelan, 1476 feet.

Springs discharge 840 cubic feet per second. Principal canal—Aryk-Ulug-nar—895 cubic feet per second.

| Rivers—                 | Cub. ft.<br>per sec. | Torrents—            | Cub. ft.<br>per sec. |
|-------------------------|----------------------|----------------------|----------------------|
| Shah-i-man-dar, . . . . | 1895                 | Aravan-sai,† . . . . | 1348                 |
| Tsfairan,* . . . .      | 2457                 | Kara-sai, . . . .    | 584                  |
|                         |                      | Sary-sai, . . . .    | 974                  |

\* The source is in the passage of Kitchi-alai, in the mountains of Thian-Shan, at 10,808 feet above the level of the sea.

† Sai or sâ signifies "water."

<sup>1</sup> *Turkestaniskia Vedomosti.*

(4.) *The District of Kokand.* Altitude of the town of Kokand, 1202 feet.

Springs discharge 1662 cubic feet per second. Principal canal—Aryk-Vuadil—285 cubic feet.

| Rivers—         | Cub. ft.<br>per sec. | Torrents—             | Cubic ft.<br>per sec. |
|-----------------|----------------------|-----------------------|-----------------------|
| Sokh, . . . .   | 3585                 | Kara-sai, . . . .     | 890                   |
| Isfara, . . . . | 2475                 | Utch-bulag, . . . .   | 380                   |
|                 |                      | Ak-tchitchek, . . . . | 156                   |

(5.) *The District of Namangan.* Altitude of the town of Namangan, 1705 feet.

Springs discharge 3348 cubic feet per second. Principal canals—Kara-sû, 1425; Janghi, 515; Shan, 685; Kosh, 95.

| Rivers—             | Cub. ft.<br>per sec. | Torrents—           | Cubic ft.<br>per sec. |
|---------------------|----------------------|---------------------|-----------------------|
| Pasha-ata, . . . .  | 2894                 | Gava, . . . .       | 445                   |
| Kassan, . . . .     | 1628                 | Tchadak-sû, . . . . | 160                   |
| Torrents—           |                      | Babai-iab, . . . .  | 130                   |
| Sumsar, . . . .     | 398                  | Padak, . . . .      | 142                   |
| Kokh-Saryk, . . . . | 180                  | Tchanat, . . . .    | 104                   |

To sum up, we have a total of 63,510 cubic feet per second discharged; on the average, by the rivers, springs, and canals in the five districts constituting the province of Fergana, with the following redistribution in cubic feet per second:—

| Districts.         | Rivers and Torrents.<br>Cub. ft.<br>per sec. | Springs.<br>Cub. ft.<br>per sec. | Canals.<br>Cub. ft.<br>per sec. |
|--------------------|--|----------------------------------|---------------------------------|
| Osh, . . . .       | 8,706  | 950                              | 105                             |
| Andijan, . . . .   | 13,807                                       | 650                              | 8,718                           |
| Marghelan, . . . . | 7,258  | 840                              | 895                             |
| Kokand, . . . .    | 7,486  | 1,662                            | 285                             |
| Namangan, . . . .  | 6,081  | 3,348                            | 2,720                           |
|                    | <hr/> 43,338                                 | <hr/> 7,450                      | <hr/> 12,723                    |

The district that is richest in water is therefore Andijan, through which runs the Kara-Daria with its tributaries; it has almost twice as much water as the district of Namangan, on the right bank of the Naryn, which, as regards volume of water, comes second. The three remaining districts together receive an almost equal amount of water, with this difference, that Kokand is more abundant in springs, Osh in rivers, and Marghelan in canals, which divert the waters of the rivers.

The above numbers must not, however, be taken too strictly, for independently of the accuracy of the measurements taken by the Russian engineer—which, according to his own avowal, were not always executed

under very favourable circumstances—the number of them, though considerable, and extending over every season during six years, is yet insufficient in such an intricate question to allow of more than an approximate estimate of the annual mean volume of running water to be disposed of.

Most of the rivers in Fergana are perennial, being fed by the snow and glaciers of the mountains in which their sources lie; but their discharge varies considerably according to the season, though we cannot give the exact numbers. The rivers Sohk and Isfara in Kokand, Pasha-ata in Namangan, and Isfairan in Marghelan are noted for their floods, which in the spring and the autumn increase the volume of water twenty to thirty times the normal outflow. For want of the necessary structures, the surplus of water in times of flood is not stored in tanks, as in Spain and India, but allowed to disperse of itself. In 1833 the damage occasioned by floods to the crops of Kokand was estimated at about £60,000; and in 1886 several districts of Fergana suffered so much from inundation that the Government was obliged to considerably reduce, and even in some cases remit, the taxes. Fields containing 100,000 acres were completely submerged in the districts of Osh, Namangan, and Kokand, and some of the land thus damaged has not yet recovered from the consequences of this disaster: swamps still remain where crops formerly stood.

Though most of the rivers are perennial, their waters do not often fill their true beds, for they are diverted into numerous canals which resemble rivers in all respects, except that they fall more gradually. Their function being not so much to drain the surrounding country as to carry off the water which descends from the snow-clad mountains, the rivers in Central Asia differ from the rivers in Europe, where rain is far more abundant; they draw a large volume of water from the more precipitous mountain regions; on descending into the plains they break up into branches or canals, and continue to be thus subdivided more and more, so as to form small irrigating canals with a scarcely perceptible fall.

The irrigated strip of land stretches along the left bank of the Kara-Daria without interruption from Bich-aryk (*aryk* signifies canal) through Marghelan and Assake to Osh, embracing Charikhana and Andijan. On the right bank of the same river, towards the Naryn on the north, there are two principal groups of irrigated lands, viz., (1) *Teki-sû-arasi* (*sû*—torrent or small river; *ieki*—two, and *arasi*—between), between the Kara-Daria and Naryn; and (2) *Uich-kurgan*, with Naûkat or Isfara in the district of Kokand. The canals in Fergana are mostly of ancient origin; they exhibit sometimes triumphs of engineering skill, the more to be admired that their constructors were totally deficient in the knowledge we owe to the researches of such men as Leonardo da Vinci, Castelly, Guglielmini, Mariot, Lombardini, and a whole host of modern names famous in pure and applied science. The breadth of the canals is from 15 to 20 feet; their gradient from 0·0005 to 0·0004; their discharge, as we have noted, varies from 1585 down to 85 cubic feet per second.

There are but few canals which have regular intakes, as, for instance, the Shaarkan and Ulugnar. The canals are connected with the rivers



by means of simple weirs made of ordinary materials, such as mud, sand, gravel, willow branches, and occasionally stones. There is no general plan adopted with the view of irrigating the largest space possible; the canals are too numerous, and there is too much capriciousness in their arrangement. The central part of Fergana is still a desert (*Khadervish*); some efforts which have been made to bring water to it by means of a canal (*Ulugnar*) have failed, but are not yet abandoned, thanks to private enterprise. The canals are administered by elders (*aryk-ak-sakal*—"canal white-beards"), elected by the community under the supervision of a Russian officer. There are, unhappily, no strict regulations and definite laws concerning property in, or control and use of, the water supply, and there is a large scope for the exercise of discretion, arbitrary conduct, and abuse. Ancient laws and customs, never clearly determined, are dying away without being replaced by new ones; and, where they still remain in force, they do not meet the new wants under changed circumstances. The maintenance of the canals, their periodical clearance from silt, which is abundant, and the general management of the whole complicated system, leave much to be desired; confidence in progress, and the necessary money for realising it, are still wanting, and, as a general result of this state of things, there is, notwithstanding the goodwill of the Government, but a slow accession to the area which benefits by irrigation. This will probably continue till the network of canals is reconstructed according to sounder principles, and a total revision of, and radical reform is made in, the laws and customs—now out of date and generally disregarded—which regulate the water supply.

**ZERAFSHAN** (in ancient times Sogo and Polytimetus).—Zerafshan signifies in Persian "that which spreads gold," and the river well deserves its name by the wealth of water, more precious than gold, which it diffuses through the fields by numerous canals. The total length of the river from its sources to the lakes, where it loses itself, is estimated at about 426 miles; of which the upper part for 286 miles belongs to Russian Turkestan, and the remaining or lower part to Bokhara. The basin which the river drains is estimated at about 14,375 square miles, of which 7285 square miles are level, and 7090 square miles are mountainous country, where the river excavates a deep channel, extracting the fertilising material which so much enhances its value. The source of the Zerafshan is in the glacier Kock-sû in the Alaï-tau, at 8500 feet above the level of the sea, and the river is known in its upper course, till it reaches the lake *İskander-göl* above Obburdan, at an altitude of about 6560 feet, under the name of Matcha, or Kohik. Then it runs almost parallel to the 40th meridian of east longitude, through a narrow and profound gorge, which expands into a valley near the town of Pendjakent, at an altitude of 3200 feet, 156 miles from the source of the river. The breadth of this upper valley of Zerafshan from *İskander-göl* to Pendjakent is from 10 to 45 miles; its fall is variable, as follows:—from 0·003 (the upper 30 miles) and 0·004 (the last 26 miles above Pendjakent) to 0·0075 along the whole middle course of this mountainous part of the river, extending about 100 miles, from Paldarak

through Obburdan to Dasht-kâsy. The mean fall of the mountainous course of the river from its sources to Pendjakent is therefore about 33 feet per mile, or 0.006 of the length. The affluents of the Zerafshan in this upper region are numerous, but mostly insignificant. The principal tributaries on the left side, which drain the northern slope of the Zerafshan range, are the Fan, the Kshtût, and the Maghian. On the right bank of the river there are only small rivulets, which drain the southern slope of the Turkestan range, but become destructive torrents after heavy rains. In its further course from Pendjakent to the plain the Zerafshan runs for about 257 miles through a large valley, which is bordered on the north by the mountains Tchumkar, Nurat, Kara-tau, and Ak-tau, and on the south by the Shakhrisab range. Here the bed of the river has a mean fall of about ten feet per mile, or 0.0019 of the length. The river has no regular tributaries from Pendjakent down to the lakes, where it is lost. It is swollen occasionally, only in the spring, by rain torrents. Some distance above Samarkand the river divides into two branches, the Ak-Daria and the Kara-Daria, which reunite about thirteen miles below the town, near the frontier of Bokhara. Here is the intake of the principal Bokharian canal, the Karaman, which conducts away the greater part of the water, which remains in the river after it has fed all the numerous canals in Russian Turkestan. During the rest of its course, the river continually decreases in bulk, in consequence of the numerous canals which issue from it on its right and left banks alternately, and runs for about eighty miles, preserving the name of Zerafshan; but at Du-aba ("Two Waters"), the greater part of its water is diverted into the canal called Shah-rûd, and the little that remains of the Zerafshan runs under the name of Karakûl for about sixty-two miles in the direction of the town of Karakûl. Two miles above this town the river breaks up into two arms, the Karakûl and the Taghy-kyr. Some twenty miles before reaching the Amu-Daria, the now nearly exhausted, but still muddy, waters of the Zerafshan flow into the marshy lakes of Denghis, Sunghur, and Karanga, which have no outlet.

The function of the Zerafshan being twofold—to drain the territory it traverses, as well as to spread over it the waters it receives from the higher snow-regions—the question of the volume of water the river carries down through the year acquires exceptional importance. The level of the water in the Zerafshan is variable; it is lowest during winter and highest in July, the volumes in the two cases being as 1 : 20. The minimum discharge in December, January, and February is estimated at 1000 to 1300 cubic feet per second; in March the snow in the lower reaches of the river begins to melt, rain falls, and in the middle of April the discharge is three times as considerable as in the preceding months. This increase of volume continues steadily, with but short interruptions, till the middle of July, thanks to the continued thaw of the abundant snow on the mountains. After having thus reached the highest limit—in the seasons of the year when there is greatest need of irrigation—the river begins quietly to subside, and reaches its minimum in autumn, with casual variations, due to the rain, which, although generally scarce, is most abundant at this season. According to the measurements

carried out at Dupul, ten and a half miles above Pendjakent, by M. Shijemsky, for the Russian government, the mean annual discharge of the Zerafshan is estimated at 8764 cubic feet per second. This is the mean discharge of the Adda in Italy. The mean monthly discharges are given in the following table:—

| Months.         | Mean Discharge in<br>cubic ft. per 1". | Months.          | Mean Discharge in<br>cubic ft. per 1". |
|-----------------|--|------------------|--|
| January, . . .  | 1,120                                  | July, . . .      | 21,950                                 |
| February, . . . | 1,400                                  | August, . . .    | 17,490                                 |
| March, . . .    | 2,130                                  | September, . . . | 12,890                                 |
| April, . . .    | 5,590                                  | October, . . .   | 6,415                                  |
| May, . . .      | 10,900                                 | November, . . .  | 3,770                                  |
| June, . . .     | 19,220                                 | December, . . .  | 2,300                                  |
|                 |  | Total, . . .     | 105,175                                |

The mean discharge of the river for the summer half-year is 14,810, and for the winter half-year 2718, cubic feet per second. This volume of water is employed in the irrigation of an area of about 287 square miles, of which about 115 square miles are in the province of Samarkand and 172 square miles in the khanate of Bokhara. As irrigation is necessary only in the warm season, we may consider that a mean discharge of one cubic foot per second fertilises about 12·4 acres in the year. This is little in comparison with the service obtained from the same unit of water in Spain, Italy, or in India, where the irrigation is conducted with far greater scientific knowledge. As Samarkand would naturally receive more than its share of the water of the Zerafshan, owing to its more even surface, irrigation works are more numerous in Bokhara.

I shall now enter into some particulars about the way in which the water of the Zerafshan is actually distributed, or, in other words, about the canals which perform the work of distribution. There are altogether 126 canals, which have their intakes from the Zerafshan, of which 83 take their supply from the river in the province of Samarkand, and 43 in the khanate of Bokhara. The entire length of these principal canals, excluding the smaller irrigating channels, cannot be less than 200 miles. The chief small canals are conducted from the Zerafshan some six miles above Pendjakent, near the village Sudjina. The chief larger canals flow from the river, on its right bank, about eight miles below Pendjakent, and on its left bank two miles further down. The most important canals are the Tuia-Tartar and Bulungar on the right, the Kasam and Dargam on the left, bank of the river. The canals immediately connected with the river serve to feed a number of secondary canals, which conduct water to single villages and estival stations. The total number of such secondary canals in the province of Samarkand alone is not less than 1000; their total length amounts to several hundred miles. The canals are not straight, but, as if in imitation of the river, sinuous and meandering; they often form ravines and gullies, and generally occupy far more space than is absolutely necessary to conduct water. The canals are traced so irregularly as to leave considerable

intervening tracts, to which the water cannot be brought, but which it should not be difficult to irrigate, by making a better use of the declivities of the ground. These remarks apply indifferently both to the canals in Samarkand and Bokhara; but whilst in the former province a greater general inclination of the surface permits the surplus water to return to the river after its work is done, in Bokhara, which is flatter, many of the canals form extensive swamps, very prejudicial to the salubrity of the air, because they are unable to carry away or otherwise dispose of the water which drains off the irrigated fields. Each canal connected with the river has to irrigate a separate oasis, but the whole area in Zerafshan subject to irrigation is divided into nine groups of oases or sections, three in the province of Samarkand, and six in Bokhara. We shall deal first with Samarkand:—(1) The uppermost section of the irrigated area in Zerafshan extends from the upper intake of the Sudjina to the point where the river divides into two branches, called respectively Ak-Daria and Kara-Daria; it is 50 miles long, and has a mean fall of 0·0036; (2) section of the Ak-daria, 67 miles long, and with a mean fall of 0·0026; (3) section of the Kara-Daria, 64 miles long, with a rather greater mean inclination of 0·0027. There are 29 canals in the uppermost section, with a total discharge during the period of floods of about 9200 cubic feet per second; in the Ak-Daria section there are 24 canals, with a discharge, in the same season of the year, of only 2470 cubic feet per second; in the Kara-Daria section 30 canals, with a maximum discharge of 7065 cubic feet per second, making a total of 83 canals, with a discharge of 18,735 cubic feet per second, or about 0·85 of the mean maximum discharge of the Zerafshan in July. This large distribution of water by all these 83 canals, which act simultaneously, is maintained during 20 to 27 days, and serves to water about 697,900 acres of cultivated land. With this area, then, and the total discharge of all the canals (18,735 cubic feet per second), we find there is rather less than 38 acres to one cubic foot of water. Taking the mean for the whole season during which irrigation is carried on, we have one cubic foot per second to about 47 acres. In India, according to Moncrieff, a supply of one cubic foot per second serves for the irrigation of as much as 250 acres, and in Italy, according to the same authority, this quantity of water suffices for 87 acres and more.<sup>1</sup> During spring—that is, in April and May—when the mean discharge of the Zerafshan is about 8720 cubic feet per second, all the water of the river is directed into the canals of the first section, whilst the two remaining sections and those of Bokhara have to be content with the water that flows back into the river after having done its work, in addition to that which, produced by rain and melting snow, descends from the mountains in torrents. It is calculated that the quantity of water brought to the fields by spring torrents, and collected by canals, makes up about 20 per cent. of the discharge of the river at this season. This water is considered sufficient for the first irrigation of the crops, and it even leaves a small surplus, which accumulates in the marshy lakes below Karakul.<sup>2</sup> The irrigated

<sup>1</sup> C. C. Scott Moncrieff, *Irrigation in Southern Europe*, p. 104.

<sup>2</sup> Denghis, Sunghur-göl, and Káránga-göl.

land in the province of Samarkand is planted with the following different kinds of crops :—

|            |   |   |   |       |
|------------|---|---|---|-------|
| Cereals,   | . | . | . | 0·40  |
| Djugarras, | . | . | . | 0·29  |
| Rice,      | . | . | . | 0·13  |
| Gardens,   | . | . | . | 0·12  |
| Cotton,    | . | . | . | 0·06  |
|            |   |   |   | <hr/> |
|            |   |   |   | 1·00  |

We will now turn to BOKHARA. The 43 canals which here tap the river of Zerafshan have a total length of not less than 600 miles. Their breadth varies from 6 to 60 feet; they distribute in summer what is left in the Zerafshan by the numerous canals of Samarkand, with an additional supply derived from rain and melted snow, which may be estimated at some 8000 to 10,000 cubic feet per second. The general mean fall of the bed of the Zerafshan in Bokhara is about 4·8 feet per mile, or 0·0009. The canals in Bokhara may be divided, as stated above, into six groups:—1. The Nakhrpai or Narupai canal, which starts from the Kara-Daria in the Russian territory; its intake is above Katta-Kurgan, its length is 62 miles, its breadth on the Russian-Bokharan frontier is 52 feet, and its estival discharge about 1167 cubic feet per second. The network of irrigating canals that are fed by the Nakhrpai covers an area of 207 square miles. 2. Three canals draw their water from the Ak-Daria, also in Russian territory, viz. the Shabat, Toss, and Damy-Ghipan; their total length is 82 miles, their estival discharge 617 cubic feet per second, and the area irrigated by them 40 square miles. 3. Twenty-five canals begin above Du-aba, some on the left, but most on the right, bank of the Zerafshan; their total length is about 340 miles, their discharge in summer is 3814 cubic feet per second, and the area irrigated by them is 248 square miles. 4. The network of canals, starting from the lower course of the Zerafshan, from Du-aba, 77 miles below the present Russian frontier,—hence called Shah-rûd. The river, 29 miles long, has here a mean fall of 0·00054, and feeds 275 canals. The total length of these canals is more than a hundred miles, their discharge in summer about 1612 cubic feet per second, and the area irrigated is 374 square miles. Among these numerous canals in Shah-rûd there are two, the Ukhary-Aylau and the Sary-Djui, which conduct the water to Syr-abat, the railway station for Bokhara. 5. The system of canals on the Vaukent or Rud-od, the right arm of the Zerafshan, which branches off from the main river by the village Sandkent, above the bridge Ishan, and carries off a quarter of the total discharge of the river at the point of junction. There are seven canals on the Vaukent; their total length is 74 miles, their summer discharge is 583 cubic feet per second, and the area irrigated is 73 square miles, at least. 6. The canals on the Karakul-Daria, also a branch of the Zerafshan, which leaves the main stream (Shah-rûd) at Du-aba, where a weir is constructed to prevent the escape of water into that channel. The Karakul-Daria as a rule is dry, but it serves occasionally as a recipient for the water escaping from the irrigated oasis of

Shah-rûd, and for that of the Shah-rûd canal itself, when the weir, as is often the case, gives way. The total length of the Karakul-Daria is 62 miles. Two miles above the town of Karakul, the river divides into two arms: the right arm, the Khak-kul, which irrigates the oasis Karakul, and supplies water to the railway station Îlat, and the left arm, the Taghy-kyr, which irrigates the oasis of the same name, and then descends into the marshy lake of Denghis. Three canals, which have their intakes on the Karakul-Daria, have a total length of 20 miles, and a very variable discharge.

To sum up, there are in Zerafshan 126 principal, and 940 distributing, canals, with a total length of not less than 2000 miles, occupying an area of not less than five thousand acres, and serving to irrigate an area of about 2758 square miles, or something less than 0·4 of the basin drained by the Zerafshan, which, as stated above, is estimated approximately at 7285 square miles.

The construction of canals in Zerafshan, though not without some boldness both in design and execution, is generally defective; the canals are tortuous, too numerous, and liable to burst and overflow. The intakes of the canals are simple cuttings in the banks, dammed up occasionally by very unsubstantial weirs of any fragile material near at hand. The cleaning and the general maintenance of the canals is most unsatisfactory, as they are allowed to be obstructed by rubbish of every kind. The environs of Bokhara are so unhealthy, in consequence of the bad air that emanates from the foul water of the canals, that in choosing the site for the Bokhara railway station, the constructors could not find a suitable position within nine miles of the town. The whole system of irrigation is a very primitive one; all the constructions to raise, dam, let out, carry, distribute, and gauge, the water are of the most simple description, and are built of materials close at hand, such as earth, fascines, stakes, branches, sand, gravel, and sometimes rough stones. The administration of the canals in Samarkand lies, as a rule, in the hands of deputies chosen by the people. There are many abuses, which the Russian Government is endeavouring to remove, but the whole question has proved as yet too complicated and delicate to be dealt with satisfactorily. As regards the administration of natural as well as artificial water-courses in Bokhara, it is, notwithstanding the vital importance of water to the land, quite deplorable. Not only are ability and knowledge wanting, but, what is worse, there are many persons interested, rather than otherwise, in retaining abuses and disorder, these being elements highly favourable to the exercise of arbitrary power. At the head of the water administration in Bokhara is placed the *mirab* (water-chief), a powerful personage chosen by the Emir himself from his immediate followers, against whose decision there is no legal appeal whatever. The *mirab* acts through *pendjabeghs*, authorised to give orders in his name, and chosen out of the members of his own family. The people are represented by *arbabs* and their assistants (*djumban*), which are deputed by the proprietors of the soil (or rather occupiers, for there is no private property in land in Bokhara) to defend the interests of cultivators. In reality these deputies are simply tools in the hands of the administration; they are constrained to execute the

orders of the *mirab* and his assistants, and it is only by means of bribery and astuteness that they can succeed in serving their constituents. For the purpose of dredging, and other regular canal work, each principal canal has a number of workmen, differing according to its dimensions and importance, assigned to it, which the *arbabs* have to raise among the people at the bidding of the *pendjabegh*. In exceptional circumstances—as, for instance, when some locality is flooded, or a weir has given way—the Emir has always the right, at the recommendation of his *mirab*, to order what is called a *mardy-valiat*—an appointment of supernumerary workmen from outlying districts. The workmen do not receive any pay or remuneration from the State; it is one of the regular burdens to which they are subjected, and the community has to pay an indemnity in money for any deficiency in the appointed number of workmen. This indemnity is paid to the treasury in the case of the *mardy-valiat*, but in other cases it is placed at the *mirab's* disposal under the name of *backy-pully*. It is asserted that the *mirab* not seldom prefers a *backy-pully*, which he can pocket, to the work of the labourers.

There is of course an essential difference between the systems of irrigation in the provinces of Samarkand and the khanate of Bokhara. In the former, constant, though not always successful, efforts are made to extend the irrigation, and to prevent waste; there is greater abundance of water, greater facilities for its conduction on account of the slope of the country, and undoubted advantages in geographical position, whilst in Bokhara abuse reigns supreme, and the deficiency in fall, as well as dependence on authorities outside the country, places this work in a condition which cannot but tell in a highly unfavourable manner on the state of agriculture and on the sanitary conditions of the country in general. This deplorable state of things will probably endure as long as the present despotic administration endures.

Central Asia shows evident signs of awakening from the long slumber in which it has been buried since the times of the immediate successors of the great Mughal conqueror; but one must not be too sanguine as to an early and successful solution of this highly important and complicated question of irrigation, which affects in an almost equal degree the agriculture, the finances, the civilisation, and the salubrity of the country. There can be no doubt, however, that under Russian rule, with increased security and better means of communication, the area of irrigated lands will go on increasing, the laws governing the use of water gain in precision, and that arbitrariness and abuse, which still find so large a scope, will decrease correspondingly. The realisation of such expectations, the problem being a technical and financial one, will of course largely depend upon the measure of confidence which the new state of things in Central Asia may inspire in Russian and European capitalists and contractors. There are already some favourable signs of increased confidence, and, for our part, we see no serious reasons why this confidence should not be bestowed in a fuller measure at this time, when peace, though costly to maintain, is yet in no great danger, and when no serious doubts can be entertained as to the peaceful tendency of Russian rule.