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THE AGRICULTURE OF EGYPT.

The following paper by Dr Milne, late of King-Edward, on the Agriculture of Egypt was then read:—

As an inhabitable, cultivable land Egypt consists of two parts—the Delta and Upper Egypt, and to these Lower Nubia is now usually added. The area under cultivation is much the same as in Scotland, about 5,000,000 acres, of which the big half is in the Delta, and but a very small part in Nubia. The population is now 10,000,000. Sixty years ago, owing to war and oppressive land taxes, it was less than 2,000,000. At its best in ancient times it may have had 7,000,000. Rain falls plentifully in winter near the Mediterranean; at sixty miles inland it becomes scanty; at Cairo a few heavy showers fall in a year; but between Cairo and Khartum rain is seldom seen. Practically the land under cultivation is limited to that within reach of the annual inundation and artificial irrigation. The average night temperature is 46 degrees F., and it never falls so low as the freezing point. In summer the day temperature is about 100 degrees F., and the workmen at the Assuan dam have to handle blocks of granite at a very high temperature, often 160 degrees F.

The Delta is an open, triangular piece of land about 150 miles on the sides, lying between and outside the two branches of the Nile, which bifurcates fourteen miles below Cairo. Upper Egypt is the narrow alluvial tract through which the Nile flows, bordered by hills 300 feet high; farther off they attain greater height. It begins about the bifurcation of the river where the hills are twelve miles apart, and extends to Assuan, 550 miles, above which is the First Cataract, though for the last fifty miles the valley is very narrow, and the rocks sometimes come close to the river. Recently the boundary of Egypt has been carried up to the Second Cataract, at Wady Halfa, 225 miles farther; but in Lower Nubia the people are black; the appearance of the country is different; there is little cultivable land between the hills and the river; seldom is a strip of land a hundred yards broad seen; and being above the reach of the Nile flood, it has to be watered artificially.

FORMATION AND FERTILITY OF THE SOIL.

About 450 B.C., Herodotus,—traveller, geographer, historian—visited Egypt, and wrote of it that it was a gained land, given to the Egyptians by the Nile. Every foot of the cultivable land in Egypt is Nile-made.

From the thickness of the annual deposit of mud by the Nile when in flood, and the depth of the alluvium in the Delta, found by borings to be lying on sand containing marine shells, geologists estimate that 50,000 years ago, with a margin of 25,000 plus or minus, the north-east of Africa was much lower than it is at present compared with the level of the sea, and that there was then sea where the Isthmus of Suez and the Delta now are. At that time the bed of the river was nearly on a level with the heights on the sides of the valley, though it is now but little above sea-level. As the land rose out of the sea, the river ran faster, and, winding from side to side, excavated a deep, broad channel in the soft limestone and sandstone rocks below Assuan. So long as the land was rising, excavation went on; when a halt occurred, alluvial deposits were left after every flood, raising the bed of the river and the land alongside about half-a-foot in a century, more or less according to the speed of the river. Another rise increased the speed so much that the alluvium was swept out to sea, and then excavation began again. At Assuan, which is a little below the rapids of the First Cataract, there are beds of alluvial mud far above the floods of the river. At Philæ, which is a little above the rapids, and all the way on to the Second Cataract, there is also alluvial mud above flood levels. These beds must have been laid down when the valley of Egypt was much higher, and extended in a uniform slope from the sea to Wady Halfa. A subsequent elevation of the land had enabled the river to remove the alluvial plain and excavate a channel much deeper than the present level of the valley. The broad valley of the Lower Nile has been cut out of a limestone called nummulite, from containing many flat, round fossils, about the size of sixpences and shillings. A few miles above Esneh new red sandstone (perhaps not contemporaneous with the British) begins, and extends far to the south in Nubia. At Silsileh, below Assuan, it is hard and of fine quality, and here were quarried the stones of which most of the statues and temples of Egypt were made. This hard sandstone was not so easily excavated as the soft nummulite limestone, and for nearly a mile the rocks are quite close to the river. Here there must have been a fall in the river for a long time after the last excavation. Forty miles farther south, beginning at Assuan and extending to the Tropic, there are under the sandstone hard crystalline rocks of the same class as those seen on the coast in the north of Aberdeen and the east of Kincardine. Through great fissures in these have come up at various times molten igneous rocks of different kinds and colours—red granite, blue diorite (our heathen), and black basalt. Curiously the term syenite, derived from Syene, the ancient name of Assuan, is not now applied to the red granite there, though both it and Peterhead granite used to be called syenite. From quarries above Assuan, in a part of the bed of the Nile now dry, were taken the great blocks of granite and diorite used by the Egyptians for statues, obelisks, sarcophagi, &c. The block from which the colossal statue at Thebes, now lying broken, was carved must have weighed 1000 tons! These rocks at Assuan prevented excavation from proceeding farther, and thus the First Cataract was formed. It is not a waterfall, but a part of the river, six miles long, studded with very many rocks and islands. The appearance differs very greatly according as the Nile is low or in flood. At low Nile the river, a mile wide, has to flow through a few channels amongst islands, and it roars and foams, though the water does not break. That the slope is considerable is shown by photographs in which we see that the centre of the stream in the widest channel is higher than the sides. Sailing boats cannot ascend without help, as the current flows at fifteen miles an hour. At high Nile the river covers many of the islands and rocks, and sailing vessels are able to go up with a favourable wind unaided. The islands extend over six miles, but only the middle half of this space has rapids. The Second Cataract is more dangerous than the First. Though the fall on the river is not so great, the islands are more numerous and the channels are narrow and tortuous. The bed of the Nile at low water resembles a bit of rubble wall, the stones representing islands, and the mortar channels. At high Nile everything is covered with water, and there is less danger than at Assuan.

After the excavation of the Nile valley, Egypt sank 500 feet, probably very slowly. This must have submerged the course of the Nile farther up than the Second Cataract, and brought the high grounds of Egypt down to sea-level. The hill near Cairo has a sea-cut terrace at 500 feet, and at another, 200 feet above the sea, there are pholas-bored holes in the rocks, and also oyster shells adhering to them. Proximity to the sea caused abundance of rain, and made the land, so dry and barren now that it is high, to be well supplied with water, and habitable. West of the Nile, worked flints found lying on the ground, 500 feet above the sea, show that it was inhabited by a primitive uncivilised people. Rising of the land followed, causing removal from the sea and decrease of rain, and the inhabitants of the high ground had to creep downwards, leaving their traces in their flint tools. After rising 500 feet, the land halted, and the river began to fill up its bed with stones and gravel brought down by the rapid current. As the bed filled up, sand and mud took the place of the stones and gravel. Then for the first time, now 6000 years ago, the valley became inhabited, and the copper found in their graves shows that the earliest inhabitants had made some progress in the arts of civilisation. As the alluvial deposit increases, the bed of the Nile rises with it, and the current slackens in speed. Thus the deposit is gradually growing finer. Stones are left behind soon after the First Cataract is passed; for a few hundred miles the annual deposit is sandy, especially near the river; further down and further from the river it is fine mud. It consists of white clay from the region drained by the White Nile, yellow clay from the Blue Nile, red sand from the channel of the river below Khartum, and brown mud from the volcanic rocks of Abyssinia. When the British soldiers were on their way to Magdala, they passed the head waters of the Atbara, which have excavated gorges 4000 feet deep in the trap rock, the debris from which has gone to form soil in Egypt. The Abyssinian rock resembles the scurdy seen south of Montrose. The Nile alluvium has been frequently analysed, and is found to be capable of supplying plants with lime, potash, and phosphoric acid; but it does not yield nitric acid. This is an aerial product, the result of the combination of nitrogen and oxygen in the atmosphere by electricity in thunder and lightning storms. It falls with the rain, and so comes to be an ingredient in the flood water of the Nile, which comes mainly from Abyssinia. If there is more virtue in the red flood water of the Atbara than in the clearer waters of the Blue and the White Niles, it is due solely to the greater amount of nitric acid it contains. But though, as Sir Alfred Milner remarks, the farmers of Egypt have a belief that the red water is the best, they may be wrong. Their belief may arise from seeing that it leaves something on the land, which the clear water does not. The Nile mud does not "muck" the land; it is not better than other fluviatile deposits, and moreover there is already in the soil an inexhaustible supply of that part of the food of crops which is derived from decomposed rocks. The difference in the qualities of the Nile waters is due to what they carry in solution, not in suspension.

INUNDATION.

In tropical countries rain depends upon the sun, being most abundant when the heat is greatest; hence the Nile is biggest in summer. In the basin of the White Nile the rainfall of the summer half-year amounts to 100 inches, but much of it goes to flood the marches above the Sobat, and a deal of water is lost by evaporation, so that the rise of the White Nile at Khartum is only 6 feet at its maximum in September. The White Nile takes its name from the pipe clay in its water when in flood. The Blue Nile, which joins the White Nile at Khartum, is small in winter, and takes its name from the clearness of its water then compared with the White Nile, though at present, owing to sudd dams, the White Nile is clear too. The Blue Nile is biggest in August, when it rises 18 feet at Khartum above winter level. Its colour is then reddish yellow. No water enters the Nile below Khartum till the Atbara comes in. It is entirely dry in March and April. It will be remembered that at the battle of the Atbara, April 7, 1898, the Arabs ran in flight across the dry bed of the river. When the sun becomes vertical at mid-day in Abyssinia, rain falls in torrents, and as the river falls 4000 feet in 400 miles, it soon tells upon the Nile. As the rains depend on the sun, whose course is regular, the floods are usually regular too. The Nile begins to rise at Assuan on June 8. The rise is felt at the head of the Delta about midsummer day, and before the middle of July the river is usually at a height sufficient to overflow its banks, if it were not banked in; but in order to give all the agriculturists an equal share of the precious water, the river sides are lined with dykes to keep it from overflowing. When the water has risen 20 feet at Cairo, the canal which supplies it is opened, and this is a signal of permission to all to let in the water to the land. This is done by opening gaps in the dykes. The water is received by canals, which extend nearly horizontally from the river to the base of the hills. These divide the land into basins of varying size, 1000 to 50,000 acres. Owing to the greater deposition of mud near the river, the land slopes towards the hills, and to keep the water from running back at once, the basins are sub-divided by cross dykes. They are also cut up into sections by innumerable small channels for irrigation purposes. As soon as the canals are full the water overflows the sections nearest the Nile; then, sluices in the cross dykes being opened, the second sections are flooded, and so on, till the whole valley is converted into sheets of water bounded by dykes. Cattle suffering from the heat or from vermin stand in the water up to their necks, trees seem to grow in water, villages and houses built on mounds stand a few feet out of the water. If the flood rise too high the inhabitants have to take to the hills with their cattle, and when they return after the flood they find their houses, which had been built with sun-dried bricks, converted into a heap of wet mud. As they build their new houses upon the site of the old with bricks made in the fields, the height of the village mounds rises with every catastrophe.

The water remains on the land six weeks. In September it becomes desirable to get rid of the water to let the land dry and be sown with the winter crops. A big basin may have two canals, one at the south side to water the high grounds near the river, and one at the north side to water the back land near the hills, which has to be very deep for some distance from the river. When the river rises too high the sluices of the canals are shut to keep it out. When it falls, the lower canal is opened to let the water off. If the river continue in flood too long, it is difficult to get rid of the water. It might be let into the upper canal of the basin next it farther north; but this the owners would object to, as they too wish to get rid of their water. This leads to making canals parallel to the river, which have to pass their water by inverted siphons under the canals running perpendicular to the river. The water must be let off gradually, because the crops are sown upon the wet mud. If the farmer cannot sow as fast as the land is laid bare of water, it soon gets hard and dry, and he has to plough it, if he has cattle; if not, it may have to lie uncropped. If not sown in good time the crop suffers greatly from the parching winds in spring. Thus it is of the utmost importance to provide for getting rid of the water in proper time. A great canal runs along the base of the hills on the west side of the Nile for 350 miles where the land is lowest, and serves first as a feeder, and then as a drain to the land in Upper Egypt. As the water stands longest in the canals, they silt up more or less every year, and are liable to get out of order, and in a season when the flood lasts too long farmers may be seen wading in the canals throwing out the semi-liquid mud with great labour, to let off the water. Often it stands till it evaporates. Keeping the canals in working order for an abnormally high or low flood entails great labour on the farmers. If the Nile does not rise high enough, there is not sufficient water to drench all the land nearest the river. In 1899 200,000 acres lay uncropped because the Nile flood was very low, the lowest for 150 years. At Assuan the Nile attains its greatest height in August. At the head of the Delta it is a month later, because the farmers of Upper Egypt are letting off water as soon as the river begins to fall. It remains at the same level ten days, the most critical time in the year. If the rise has been 25 feet at Cairo everything goes well; much less brings a deficient sowing; much more brings disaster, undermining the banks of the river and flooding the land to a great depth. In the Delta especially a very high Nile is ruinous. The canals are constantly silting up, and are consequently rising above the land on either side. If a feeding canal breach its banks the adjacent country is inundated; cotton, sugar-canes, and rice are ruined; cattle cannot be removed, and are drowned; even human lives are sometimes lost when village mounds are covered. The rise begins at midsummer, the fall is expected at the autumn equinox, and by midwinter the river shrinks within its usual bed. In the end of October the farmer likes to sow his winter crops—wheat, barley, rye, clover, beans, peas, lupins, lentils, flax, and hemp. After the flood, no water can be got from the river unless by lifting it by artificial means.

IRRIGATION.

If a farmer has sown the whole of his land for crops he has nothing to do till next year but weed them during the winter, reap them in spring, and put his canals in working order, letting his land lie waste all summer. This leads him to raise water by various contrivances to grow summer crops of vegetables by irrigating the land on a small scale. In this way a great variety of plants are grown for food in gardens divided into sections by small channels kept full of water, which can be turned on and off at pleasure as the crops need it. Those far from the river sink wells, and find an unfailing supply of water at a depth of thirty to forty feet. Those near the river make canals deep enough to bring in a supply from the river bed, even at its lowest, and those upon the bank lift it directly from the river. In the Delta steam pumps are now largely used for raising water. Farther up the river, especially between Silsileh and Assuan, the shadoof is employed. It consists of a long pole hung by straps from a cross bar, which rests upon a forked tree stump, or on two walls built of mud bricks. At one end is a heavy weight of mud, at the other a long slender palm stem tied to the pole and having a bowl at the lower end. Standing on a level with the cross bar, the worker pulls down the point of the pole, dips the bowl in the water, pulls it up aided by the heavy weight, and pours the water into a trough which conveys it to the land. Sometimes it needs four shadoofs to raise the water high enough to run upon the land. Between Silsileh and Assuan a great number of men may be seen at one place working the shadoof industriously all day long, raising a great deal of water, and content with 5d. per day. Two men by a big bowl and four ropes, two each, can lift more water, but it is harder work. More efficient machines are water-wheels, worked by cows, bulls, oxen, or camels. One kind has a vertical wheel with boxes in the rim, opening to the side, dipping into the water. On the same axle, but at a little distance, is a cogged wheel driven by a horizontal wheel with cogs projecting downwards. Instead of the boxes earthenware jars tied to the outside of the rim, with their mouths turned to the side, may be used. If the water has to be raised to a great height, the jars may be attached to two chains or ropes passing over a small cogged wheel, which works in cogs on the rim of a horizontal wheel, high enough up on its axle to let the beast which drives it walk below. The chain of jars hangs down loose, and they go up and down perpendicularly. A boy to drive gets 2½d. per day, but often the machine has to work night and day, and relays are needed. In the district called The Fayoum, which is 140 feet below sea-level and is watered by the long canal already mentioned, now fed from the Nile, a self-acting elevator is used. A great wheel, over 30 feet in diameter, has the usual chain of jars on the edge of the rim, and, projecting beyond these, aves or water-boards, as in an undershot wheel. A stream of water let on at the level of the axle turns the wheel, and fills the jars: they discharge their contents into a high level trough to water the high ground; spare water from the mill-lade waters land at a lower level; and the water passing under the wheel serves for the lowest ground, and any surplus runs into a lake at the lowest part of the district, where it is evaporated. Machines made in Buenos Ayres, upon the principle of the Egyptian water-wheel, are used in Argentina to raise water for live stock in times of drought. They are simple and not liable to go out of order, an important matter in a rural place many miles from a town. By these contrivances three crops are grown in a year—one sown at the usual time in October, another in March, and a third in July. In Nubia, where the alluvial land is far above the level of the river, owing to the gradual filing away of the rocky bed at Assuan by sand, carried in suspension by the water, hardly anything can be grown without using a water-wheel. The success attending irrigation on this small scale led to schemes for supplying water on a greater.

Egypt was occupied by the French from 1798 to 1801, and Napoleon, seeing the advantage that it would be to Egypt to have the means of regulating the water supply and securing irrigation for a summer crop, proposed to make a dam across the Nile at the head of the Delta. The French had to evacuate Egypt and the project was given up. Mehemet Ali began to make a dam in 1833, but soon stopped. In 1842 a French engineer persuaded him to resume operations, and a place was selected just below where the Nile divides into two branches. The works, called The Barrage, consist of two dams in the form of bridges, each with 61 arches, crossing the Rosetta and the Damietta branches of the river, a revetement or wall crossing the head of the Delta, and three canals, one to carry water for the land between the branches, and two for the land outside. The bridges are each one-third of a mile long, the revetement two-thirds, and the total length of the works is more than a mile. The Barrage took twenty years to construct, and cost £2,000,000. The arches, 16 feet wide, were to be closed by iron gates let down by winches travelling on rails along the bridges. Only the Rosetta branch had its gates in position, and it was tried in 1863. When the gates were let down the Barrage cracked and began to give way before the pressure of the rising water, and the gates had to be opened. The Barrage had been founded on concrete laid on stones and gravel thrown into the bed of the river, and water forced a way under the concrete and rose up below the gates. At most the Barrage had raised the water twenty inches. In 1867, it sustained further injury, and was after that let alone. In 1883, twenty years after it was made, the Barrage was declared useless, and a hindrance to navigation, and arrangements were made for blowing it up; but the estimted cost was so great that it seemed as cheap to repair it. Some repairs were made upon it in 1884, and it was found capable of doing some good. Further repairs enabled the water to be raised 8 feet. This success led to a thorough repair being undertaken, and two Anglo-Indian engineers, experienced in Indian irrigation works, were employed to effect it. So great benefit had been derived from the temporary repairs that the work had to be carried on without lowering the water dammed back. Half of a bridge was taken in hand at a time; the foundations were laid dry by coffer dams, and strengthened and extended. By 1891 the work was completed, and found capable of raising the water of the river 12 feet. The cost with accessory works was a million sterling; but it immediately effected a great saving of money and work. There had been a heavy annual expenditure for pumping water for irrigation, much of which was now saved, and often there had not been water to pump; now there was plenty. There had been great silting in the irrigation canals, because they were deep and level; now that the water was delivered at a higher level they did not require to be so deep, and there was much less silting to remove annually; £200,000 was saved on pumping and cleaning. Two crops could now be grown in a year, one of them cotton, which thrives best in the warmest season. The sugar-cane, too, could be grown. It is a perennial, though usually it is taken out after growing three years, and must have water all the year round, but it does not stand inundation. Rice grows best in a hot climate, and needs much water at intervals. By irrigation these crops could be grown, and now three-fourths of the value of the exports of Egypt comes from cotton alone. Besides, nearly 2,000,000 acres of land was reclaimed. In the time of the Pharaohs the population of Egypt was probably seven millions. By bad government it had been reduced, and in the early part of this century it did not amount to two millions, consequently much land had gone out of cultivation for want of labour to attend to water.

Great areas only required water to grow luxuriant crops. But there were others, some wet, some dry, useless owing to the amount of salt in the soil. One per cent. of salt in the soil kills all animal and vegetable life and renders it barren. Near the sea there are lagoons, separated from it by bars, over which in storms salt water is thrown. These are barren. But in the interior there is much land too salt from quite a different cause. The sea is salt because all the salts of every sort brought to it by rivers out of the land remain in it when the water evaporates, and it is growing salter every day. The water of the Nile and its tributaries is not originally salter than that of other streams; but standing in marshes in the Sudan, 10,000 square miles in extent, and flowing under a cloudless sky in a stream 1000 miles long and a mile broad, all the way between Khartum and Cairo, it has lost perhaps a fourth of its volume, and has therefore become salter. When the land is inundated the water sinks down into the ground several feet, but in many cases it does not go so far down as to mingle with the water filtering in from the Nile. In the course of drying, the flood water rises to the surface and brings up its salt with it, but leaves it there when it evaporates. Hence the surface soil becomes so salt that it grows white where it is dry.

So long, however, as it is inundated and a portion of the water is allowed to flow off, the soil though salter than land in this country grows crops well enough; but when flood water is allowed to dry up altogether and none runs off, the land very soon becomes too salt to grow anything. In the United States much land is barren from excess of carbonate of soda. There was much land in the Delta too salt to grow anything, and it was incurable by inundation, because even though water could have been put in, it could not be got off again, as the irrigating canals went all over the country, and the water in them was higher than most of the salt areas. The cure for salt barrenness was found in irrigation combined with drainage. It was effectual, but expensive; wide, deep drains had to be made to receive the irrigation water after passing through the soil, and inverted siphons had to be provided to allow the drainage water to pass under the feeding canals on its way to the sea. A million of acres have been reclaimed by watering alone, and another by watering combined with drainage. Altogether the Barrage has benefited the Delta region £3,000,000 annually by saving pumping, lessening silt, watering dry land, reclaiming salt land, and enabling two crops a year to be grown instead of one. Gradually inundation is giving place to irrigation in the Delta, both because it is wasteful of water, now becoming scarce with extended cultivation, and because it wastes two full months of the best growing season. The officials who have seen so much of the evil done by excess of salt, and have done so much to remedy it, are apprehensive that to give up the annual inundation and grow both summer and winter crops by irrigation would, with a diminished supply for copious irrigation and drainage, bring on saltness again. Very likely it would if only grain crops were raised; but some crops, such as turnips and cabbage, can tolerate a good deal of salt, being originally sea-side plants, and all succulent crops remove large quantities of salt from the soil. The urine of cattle eating a large quantity of turnips must be greatly diluted, yet it contains so much salt that it kills grass when allowed to flow over it. Hence, with judicious cropping, as much salt may be removed annually as is put in by irrigation.

In February 1898 the Khedive announced that in order to remove all anxiety regarding the stability of the Barrage, now doing so much good, the Egyptian Government had resolved to make weirs above and below the Barrage. Considerable progress has been already made with the works, and it is hoped that these will also add to its efficiency and enable the water to be delivered at a higher level into the canals.

RESERVOIRS IN UPPER EGYPT.

The success of the Barrage at the head of the Delta led to a desire to regulate the supply of water for Upper Egypt also. There is not much that can be done to increase the extent of cultivated land, because owing to the sloping of the surface away from the river, the ground farthest off is more easily watered than the nearest; but a regular, unfailing, sufficient supply could be provided; the land could be irrigated during the dry season; and a constant succession of crops could be grown, some of which grow best with great heat. Great as was the increase of the produce of the Delta, it is calculated that more could be done in Upper Egypt, and £4,000,000 a year could be added to the produce of the land by dams to make reservoirs. If any land were reclaimed, it would be worth £20 per acre, the price paid for reclaimed land in the Fayoum.

For several years it seemed impossible for the Egyptian Government to provide the money for making the dams, owing to the jealousy of France, which thought that the prosperity of Egypt would increase the influence of Britain more than of any other European country. The extravagant expenditure of Mehemet Ali had saddled Egypt with a debt of £100,000,000, borrowed at a high rate of interest, which it was unable to pay. At the request of the Khedive, six European Powers, whose subjects had lent the money, took in hand the finance of the country, and enabled Egypt to come to terms with its creditors. A commission was appointed to pay the tribute to Turkey and the interest of the debt, needing nearly £5,000,000 per annum, for which purpose a certain part of the revenue was assigned to the Commission. It was made a stipulation that if the revenue yielded a surplus, half was to be given to the Government and the other half was to be retained by the Commission as a guarantee against loss of revenue in bad years. Another Commission was appointed to collect the whole revenue and pay the debt Commission its portion, and hand over the rest to the Government for national purposes. The debt Commission soon began to prosper and had annual surpluses, half of which it hoarded up and half it paid to the Government, which was chronically in need of more money than it was deriving from taxation, chiefly to reduce the heavy taxes paid by the farmers. Without the unanimous consent of the six Powers represented on the Commission, no part of its savings could be touched to make the dams, and France refused its consent. The only taxes that could have been increased to raise money were those assigned to the Commission, and to pay the interest of a loan to make dams it would have been necessary to tax for twice the amount necessary, because the Commission would have claimed the half. The project of supplying Upper Egypt with water to grow summer crops had to be given up, although no one doubted that a supply of water for summer crops could be provided at a cost which increased revenue from land would amply repay within a moderate time. Various schemes had been proposed, all of them comprehending a dam built on the solid rock at the head of the First Cataract, where the level of the water at low Nile is twenty feet higher than at the bottom. Philæ and some larger islands at the head of the insular tract are in quiet water where the river is wide. A quarter of a mile lower the width of the river is less, the slope of its bed is greater, and it rushes violently through five or six channels, fifty to a hundred and fifty yards wide, besides many smaller gaps. It was proposed by some to make here a dam high enough to raise the level of low Nile a hundred and twenty feet, which would have made the Nile stand back to the Second Cataract, 225 miles. A great objection to this proposal was that the island of Philæ would be covered with water. On it there are some buildings much valued by archæologists and artists—the temple of Isis, Pharaoh's bed, and others. To save these there was another scheme by which the water would be raised only forty-eight feet. If it were raised sixty-five feet the two buildings mentioned would still be above the water, but Pharaoh's bed, being founded on Nile mud, would probably collapse.

After the idea of irrigating Upper Egypt had lain in abeyance several years, it occurred to some Englishmen wintering in Egypt that the money might be raised privately, and they made proposals to the Government, which were accepted. On February 20, 1898, the Khedive, in Council, sanctioned a contract with Messrs John Aird & Company for the construction of a dam at Assuan and another at Assiut, to be completed within five years; and the contractors agreed to accept as payment deferred pay warrants for £5,000,000 in thirty annual instalments, commencing on the completion of the works. Aird & Company transferred the warrants to a commission, which supplied money as wanted for the works. On offering for sale about half-a-million of the warrants, bearing interest at 4 per cent. till paid, the Commission instantly received applications for eleven millions. This showed public confidence in the skill of the contractors to make the dams, and in the success of the undertaking. On the terms of payment the contract could have been executed for half the money, cash as required for the work. The "Times" newspaper had received a telegram announcing the contract, which it published next day in an extended form as a paragraph, and the day following still more expanded in a leading article. The paragraph was repeated by other newspapers, and the country was inundated with statements regarding the dimensions and the objects of the dams, which seemed to have the authority of the Khedive, but were afterwards seen to be erroneous. The "Times" put it that the Assuan dam would be 76 feet above the river bed, and would raise the water 46 feet. "Great Thoughts" magazine made the dam 70 yards high. The Assuan dam will be capable of raising the level of the river 65 feet above low Nile level. It will be 2000 yards long, 80 feet wide at the base, and about 80 feet high on an average, though in the deepest parts of the channels, which are much deeper than was expected, it will be nearly twice as much. The wall is to be built of solid granite, coursed ashlar outside, and rubble inside, all laid in cement. On the west side of the river there will be a navigation canal with locks. Work was begun immediately, and next year, February 12, the Duke of Connaught formally laid the foundation stone, though much work had already been done. Preparations were begun by shutting up some of the eastern channels with blocks of concrete, bound together with steel wire, to divert the water. Below these temporary dams a foundation trench has been cut through the islands and across the bed of the river, as far as practicable. When the rising of the Nile stopped work last year in August last, four channels had been closed, and the foundation had been laid of more than half the length of the dam. Photographs show a good deal of batter on the wall, and the beds of the outside facing sloping inwards. When finished, there will be a broad roadway along the top, from which sluices for closing the gates can be worked. There will be 180 openings in the dam, at intervals of about half a chain. The sluices must be kept open at the bottom while red water is running to prevent silting up.

The Assiut dam is to be 300 miles below Assuan, where the river is half-a-mile wide. It will have a navigation canal with locks at the west side. Preparations began with making coffer dams in the bed of the river, and driving cast-iron piles in the bottom of a deep excavation. On these was laid a bed of concrete, 10 feet thick and 87 wide. Upon this a wall of granite will be built, with 111 openings, 16 feet wide, capable of raising the water of the river 8 feet. The chief danger apprehended is percolation of water below the wall, to prevent which sheet iron piles were driven deep below the foundation on both upper and lower sides. It was hoped that the whole foundation would be laid before the Nile rose, but the coffer dam was burst in, August 23, and work had to be suspended. A great amount of work was accomplished last season by working day and night, using electric light when there was not moonlight. When work stopped 23,000 men, of whom 20,000 were natives, were emplayed partly at Assuan and partly at Assiut. The natives have nothing to do in summer, and are usually ill off then; the wages earned at the dams will enrich the native population. The other 3000 are mostly Italian granite workers, who earn very high wages—about £1 per day; but the work with the sun overhead handling stones at 160 degrees F. is very trying to Europeans. By the end of 1900 it was hoped that the foundations would be all laid, and then many more men could be employed. Hopes are entertained that the works will be completed a year before the time stipulated. When they are completed, the Nile will stand back 140 miles at Assuan, and 40 miles at Assiut.

The "Times" is responsible for the statement —among others—that the dams will serve the double purpose of storing water in relief of abnormally low Niles, and of mitigating the violence of exceptional floods. They are not intended to do either of these things. The sluices will be open while red water is running to prevent silting. Then they will be closed till the reservoirs are full, and more water is needed for growing crops than the river can supply. After that the water will be doled out carefully to supply irrigation for summer crops till the red water begins to flow. The Assiut dam will have for its main object the feeding of a new canal opening in the west bank, half-a-mile above the dam. This canal will be 80 yards wide, and will carry water for the Fayoum and all the district on the west side of the Nile below Assiut. In some parts it may give water at a level high enough to irrigate without lifting machines; in others it will supply water at a much higher level than farmers can procure it at present, and so reduce the work of raising it. The Assuan dam will supply water all along the highest line of land, that alongside the river, for the district 300 miles north of Assuan. The demands on it will therefore be greater than those upon the lower dam; but having greater storage it may be able to spare some water for the wants of the Delta, where the increased area of cultivated ground needs more water than it can get at present after the Nile falls. The new dams will not add much, if anything, to the land watered by flooding; probably they will greatly diminish it by introducing sugar-cane growing, which inundation would ruin. In Upper Egypt the people are ill fed in summer, which tends to keep down the population. With summer water, food will be abundant, and the population may double itself in twenty years. The women have large families, and all marry before they are 18. Above Assuan the dam may possibly flood some cultivable land for the last five months of the year; but there will be time for a spring crop. The main effect of it will be to reduce the labour of the farmers by giving water at a higher level. Population is thin in Nubia, and there may be an increase by making food more easily procured. There is every reason to think that the dams will cause a demand for water greater than they can supply when summer crops are generally grown. How is it to be met?

THE SUDD.

From the sea to Wady Halfa, 840 miles, the Nile has a fall of 6 inches per mile; thence to Khartum, 820 miles, 12 inches; thence to Lado, 890 miles, 4 inches, and in parts of this last stretch the river is 40 feet deep. The feeble current could not have excavated pools so deep, and probably only the northern part of the river's course rose at the last elevation. To get more water for irrigation it has been proposed to make more dams on the river, one at the Fifth Cataract below Berber, and another at the Sixth below Khartum. A dam at the Sixth Cataract would do more harm than good. The current of the White Nile is already so slow that it is not able to clear its way for 150 miles above its junction with the Sobat. From time immemorial, as is shown by hieroglyphics in Egypt, the Nile has been liable to be blocked up by floating vegetation, which obstructs traffic and retards the current of the river. It is caused by a water plant growing in the river below Murchison Falls. It resembles London Pride, and has many heads, each like a small cabbage, which are easily broken off by crocodiles, hippopotami, and large fishes. They go sailing down the stream, sending out roots 12 or 18 inches long, which dangle in the water. On arriving at the pools and marshes between Lado and the mouth of the Sobat they are stopped in their course by reeds, and rapidly accumulate till they extend across the river. This retards its flow, and another obstruction forms a few miles farther up, and so on, till a place is reached where the river grows rapid.

These obstructions are immovable, and instead of decreasing by decay, they increase in thickness by accumulations below and above, till they become so thick that hippopotami can walk upon them. They are called sudds, a word meaning barriers. The Nile was cleared of them five and twenty years ago, but they grew again, and in 1899 they stopped the flow of the Nile so much that the annual inundation was the smallest known for 150 years. To remedy matters £10,000 was allotted by the Egyptian Government to clear the river, and an expedition set out with a steamship provided with wire ropes and cutting instruments. The first sudd was cut up into large blocks, which were pulled down the stream by the steamer by means of the wire ropes. By great energy the river was cleared of all the barriers, which extended over nearly a hundred miles. In pulling them asunder the bodies of dead crocodiles and hippopotami were found embedded in them. The immediate result was a rise in the White Nile, and the setting free of a great quantity of water which had been stagnating so long that it had lost all its oxygen, and hence proved fatal to the fish in the river as far down as Assuan. It was suggested by an engineer that willows should be planted in the marshes, leaving a clear space for the river. This was found to be quite impracticable, as the marshy country is 10,000 square miles in extent, and in many places there are deep pools 20 to 30 and even 40 feet deep. Another suggestion made is to fence in a clear space for the river, and make groins to catch and turn aside floating things. Most likely it would prove too great an undertaking to put up suitable wire fences, and they might not prove effectual, as the river is not dammed back, but only retarded by the sudds, which float on the surface of the water. Such being the state of matters above the infall of the Sobat, it is certain that a dam at Khartum would still farther diminish the current of the river farther up, and probably make things worse than they are. A plan more likely to be beneficial would be to blast out all obstructions in the river for some distance below Khartum. This would increase the speed and scouring power of the current, and might draw off the water from the pools and marshes, greatly reducing their extent. Besides retarding the flow of the river, the sudds, by expanding it, cause most serious loss of water by evaporation. It is believed that the Nile loses one foot per month of the depth of its water in its course between Khartum and the sea, and hence it is estimated that more than half of the rainfall in the basin of the White Nile above Khartum is lost by evaporation. If the current of the river were increased so as to clear it of sudds, twice as much water would come down the White Nile in its flood season, which is in September. It then rises 6 feet above its low level, and has twenty times as much water. Clearing its course would have a two-fold effect: it would accelerate the arrival of its flood water at Khartum, and by lessening evaporation make it continue longer in flood. The rainy season in Abyssinia is soon over; but in the basin of the White Nile rain falls pretty steadily from February to November.

There is good ground for believing that the increase of revenue accruing from the works now in progress will in a few years enable Egypt to shake off the incubus of the Debt Commission now holding her down, and to effect economies in her heavy expenditure. The influence of Britain will prevent her from wasting her strength in maintaining a large army, and she will then be able to devote herself to increasing the flow and economising the water of her river, her only source of wealth. Though the progress of Egypt during the last ten years has been unparalleled, we may hope that the next decade will surpass the last in the increase of her prosperity and population.

A vote of thanks was very cordially passed to Dr Milne, and the meeting ended.