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The Nile, Egypt, and the Sudan.

THE latest publication of the Public Works Ministry of Egypt is of more than usual interest, for it not only appears at a time when work is being resumed after being stopped, or at least largely restricted, during the war, but it also sets forth a large collection of data relating to projects which have met with criticism in some quarters during the last three years. A year ago the Nile Projects Commission was appointed to report upon the physical data upon which the engineering plans were based, and this Commission has now unanimously accepted Sir Murdoch MacDonald's evidence and approved his designs for the series of irrigation works described in the report before us.

A small amount of rain falls annually on the Mediterranean shore of Egypt, but this diminishes rapidly as we go southwards, so that it is of no value to agriculture, except for the winter crops raised by nomad tribes west of Alexandria. All the water that the increasingly intensive cultivation of Egypt demands must be supplied by the Nile, and recent surveys have established that there are about $7\frac{1}{2}$ million acres which can be perennially cultivated if the necessary water is forthcoming at all seasons.

Fed by the summer rains on the Abyssinian tableland, the Nile begins to rise in Egypt in June, and reaches its maximum level in September, after which it falls slowly, the contribution of the White Nile delaying the reduction of the levels to a very appreciable extent. The task, therefore, of those in whose charge the control of the Nile water rests is to utilise the surplus water of the flood or of the river in the early stages of its fall in order to supplement the supply in the early summer, when the discharge is wholly inadequate to meet the demands of agriculture. From 1886, the earliest year for which statistics of the cultivated areas are available, there has been a steady increase in the area perennially cultivated, until now the area is greater by one-third, or more than a million feddans,[2] than it was in 1886 As some land is double-cropped, the total crop area now requiring water is somewhat more than $7\frac{1}{2}$ million feddans.

While this rapid extension of the area under cultivation has been taking place, the population of Egypt has been increasing at a notable rate, and while it stood at $7\frac{1}{2}$ millions in 1886, it numbered $12\frac{3}{4}$ millions in 1917; consequently, the cultivated area per head of population, which in 1886 was 0·65 feddan, in 1917 was 0·42 feddan, and the crop area had fallen from 0·89 feddan to 0·60 feddan. Thus one result of an improved administration of the country has been to increase the demands upon its irrigation in much the same proportion as new projects could be designed and carried out.

For the first decade after the reconquest of the Sudan in 1898 the lands bordering on the Nile and those areas where the summer rains made cultivation practicable sufficed for the support of the population which remained after fifteen years of Dervish rule. In 1903 experiments were made to test the feasibility of producing, with the aid of irrigation, crops suitable for export, such as wheat, sugar, and cotton; and the area which might be so cultivated in the Sudan was fixed at 10,000 feddans, an amount which was increased to 20,000 feddans when the Aswan Dam had been raised to its full height. It was now evident that the Sudan could in time utilise a much larger area of the fertile Gezira, the tract between the Blue and White Niles, if sufficient water could be taken from the Nile without prejudicing the supply required by Egypt; and the projects now described, which have been in preparation since before the war, have been designed to supply water for an area of 300,000 feddans in the Sudan, while safeguarding at the same time Egypt's requirements.

Accurate gauging of the volume discharged by the Nile at all stages was of the first importance,

1 "Nile Control." By Sir Murdoch MacDonald, Adviser, Ministry of Public Works, Egypt. (Cairo: Government Press, 1920.) Price 20 P.T.

2 A feddan is equivalent to 1·038 acres.

and much criticism has been directed against the tables of discharge which the Public Works Ministry has published; but there are no valid grounds whatever for doubting their correctness, and the accounts given of the rating of current-meters in this report, the accuracy of the discharges measured with them, and the method of measuring the volume discharged through the sluices of the Aswan Dam, show that the greatest care has been taken to obtain as high an accuracy as possible. The report of the Nile Projects Commission, which has just been issued, affords a complete vindication of the accuracy of these measurements.

In the early days of the British occupation of Egypt the reorganisation of the irrigation of the country was recognised as being of the first importance, and every improvement that was achieved produced large returns in the shape of increased economic prosperity. But as the margin of possible improvement grew narrower with each advance, greater precision of measurement became necessary, and for some years a special branch of the Public Works Ministry has been engaged upon the scientific investigation of all the problems of Nile hydrography. The necessity for this was clearly shown in the exceptionally low flood of 1913, and in the consequent deficiency in the supply in the following spring and summer. The volume discharged by the river in this exceptional year was only 41,000 million cubic metres, whereas the total requirements of Egypt and the Sudan by 1955 are estimated to reach 56,000 million, so that additional works must be constructed, even though such an extraordinarily low flood occurs but rarely. The Blue and White Niles, from which this additional supply must be obtained, differ fundamentally in their hydrographic character. The Blue Nile, with a comparatively short course of approximately 1500 kilometres and a fall of 1400 metres, carries a heavily silt-laden flood past Khartum which may reach and even exceed 9000 cubic metres a second. The White Nile, on the other hand, has deposited most of its load in the marsh region of its upper reaches, or on the plains of the Sobat River, so that its waters are clear and can be stored in a reservoir; also the shallow valley of the White Nile, with its exceedingly low slope, allows a very large volume to be held up by a work of moderate height.

The present scheme provides both for a dam across the White Nile valley at a short distance upstream of Khartoum, and for a dam on the Blue Nile near Sennar. The site selected for the White Nile dam is at Gebel Aulia, 45 kilometres upstream of Khartoum, where the valley is wide and shallow. A continuous masonry dam 5 kilometres long and further extended by 1½ kilometres of an earthen dam with a masonry core wall will hold up the waters of the White Nile to a height of 8 metres above summer river level, and to 9·5 metres in years of high flood; it will thus provide an additional 4000 million cubic metres of water for the development of Egyptian agriculture and for the reclamation of the northern shore of the Delta; it will also act as a protection work in high floods by holding up water until the crest of the Blue Nile flood has passed and the White Nile water can be released without danger. Evaporation over the surface of the reservoir which will be formed by the dam will be large, for the maximum area is 540 square kilometres, and observations show that it will amount to 11 mm. per day in April, and to 2·4 mm. in the rainy season when allowance has been made for the rainfall. The loss by absorption over the area of the reservoir must also be considerable, and 1 cubic metre of water per square metre of surface has been allowed for this.

For meeting the requirements of the Sudan, a dam is proposed on the Blue Nile near Sennar, and the one which has been designed will be a solid masonry structure of granite, with sluices and spillways sufficient to discharge 15,000 cubic metres per second. By the control which this dam will afford, such water as is needed for use in the Gezira can be withdrawn from the Blue Nile from July 15 to January 18, after which the reservoir upstream of the dam will supply the further requirements of the Sudan in order that the water flowing in the Blue Nile may pass on to Egypt without diminution.

The data relating to both these schemes are set out fully in the report, from which the amount of water which is required for the agricultural development of different regions at each season can be seen, and the provision for meeting these requirements by means of the storage and control provided by the dams at Aswan, Gebel Aulia, and Sennar can be readily examined.

Some subsidiary works will be needed, and one of these is a barrage at Naga Hamadi, in Upper Egypt. One effect of filling the new storage reservoir by means of the White Nile dam will be to lower slightly the maximum of the flood at Aswan, and, consequently, to make the watering of the higher lands of Upper Egypt more difficult. The conversion of land in this part of

Egypt from basin to the perennial system of irrigation is now due, and to meet these needs this barrage will have to be constructed.

Besides these works which are about to be constructed on the Blue and White Niles, two other projects of which the need in the future can be foreseen to complete the control of the Nile supply are briefly discussed. One of these is the Lake Albert dam, by means of which it is proposed to hold up a reserve store of water in the Albert Lake, which will be conveyed to the White Nile by a channel or channels so planned as to avoid the loss of water which now takes place in wide, shallow valleys where the sadd marshes are situated. The other scheme, which is even more briefly outlined, is the provision of a dam on the upper reaches of the Blue Nile to store 7000 million cubic metres of water, of which part would be kept as a permanent reserve in case of low floods, and the balance used to irrigate the cotton crop on one-third of a million feddan area in the Sudan. Nothing has yet been done on either of these projects, and no details are published in the report; they are only indicated as works which must eventually be undertaken to provide the necessary water for agriculture in arid and semi-arid areas of the Nile basin.

The report contains a large amount of valuable information on the utilisation of water under the special conditions which prevail in Egypt. The requirements of agriculture are fully stated by the responsible authorities of Egypt and the Sudan; detailed estimates of the amount of water which is available at various seasons are also given as the result of a long series of measurements which have been made in recent years. This collection of hydrographical data brings those which were previously available up to date, and supplements them by much information of greater accuracy on which the present projects have been based.

With a rapidly increasing population the occasional occurrence of such disastrously low floods as that of 1913 has carefully to be guarded against; on the other hand, the growing demands of cultivators in Egypt, and the needs of the Sudan, which will be increasing for years to come, call for the most careful investigation of the hydrography of the Nile, for, while the supply of water is shown to be sufficient to meet all anticipated requirements, this can be done only by a full control of the supply and a careful regulation at all seasons by suitable works.

Poynting's Scientific Papers.

Collected Scientific Papers. By Prof. J. H. Poynting. Pp. xxxii+768. (Cambridge: At the University Press, 1920.) Price 37*s.* 6*d.* net.

THESE papers make a stately volume of considerably more than 700 pages, and our thanks are due to the editors, Mr. Guy Barlow and Dr. Shakespear, for the ability with which they have performed their work, a work which, as old pupils of Poynting, must have been to them a labour of love. The volume contains an excellent portrait, and the type, paper, and binding are worthy of the Cambridge University Press. I think everyone, even though he may have thought himself well acquainted with Poynting's work, will find here something which he sees for the first time, for the volume includes not only papers from such normal sources as the Transactions and Proceedings of the Royal Society and the *Philosophical Magazine,* but also others from the *India Rubber Journal,* the *Hibbert Journal,* the "Encyclopædia of Biblical Literature," the *Mason College Magazine,* and the *Inquirer.* In addition to the classical papers on the flow of energy in the electromagnetic field, on the pressure of light, and on the density of the earth, there are others on the drunkenness statistics of the large towns, on the fluctuations in the price of wheat, on the experiences of one who overtook the waves of light, a criticism of Herbert Spencer's "First Principles," and a paper on physical law and life. To those who knew Poynting, these informal papers have a special charm, for they will find in them much that will recall memories of long-past talks; they recall his quiet humour, the freshness of his views, his courtesy in debate, his dread of saying or doing anything that could hurt the feelings of anyone who did not hold his own views on the point at issue. Among the seventy papers in this book, there are not more than two or three that could be called controversial, and it is characteristic of these that he criticises his opponent as if he loved him; and, even when the author under notice has laid himself more than usually open to criticism, Poynting is not content with pointing out the unsoundness of his statements; he suggests that he must really have meant something else, something much more reasonable.

Another feature of the book is that running throughout the papers is a view of the philosophy of physics which is now very prevalent, but which Poynting was one of the first in this country to adopt. This view is summarised in the paper on "Physical Law and Life"; and though this paper