No. 1,615.—“Irrigation in Ceylon.” By HENRY BYRNE, M. Inst. C.E.

THE circumstances of Ceylon, as regards the benefits of irrigation and the methods of practising it, are so similar to those of India, that in view of how thoroughly the subject has been treated in the Papers relating to Indian irrigation in the Proceedings,¹ some apology is needed for any remarks in reference to the smaller of the two countries.

Three different methods of obtaining water for irrigation are practised in the Island: 1st. Raising it by manual labour from wells and ponds; 2nd. Collecting it in tanks fed by the drainage of the neighbourhood; and 3rd. Tapping the mountain streams and torrents.

The first of these is adopted in the small densely-peopled district at the extreme north of the island, known as the Jaffna Peninsula, and in a few other places where the country is so uniformly flat as to present no site for tanks of the ordinary Indian type, and where there is no river or other natural source of fresh-water supply but the direct one of the periodical rains. Garden cultivation is, however, the only one to which the system of irrigation from wells is applicable; because it alone is sufficiently profitable to pay for the labour involved, and because less water is required for it than for the cultivation of rice. Rice is certainly grown in the district, but to a very small extent, and only where the lands are unfit for other purposes; for, a successful rice harvest there depends upon the rainfall, which is very uncertain, and upon the ponds, which often fail, but which when full yield a supply of water in aid of the rains. The water is raised from these ponds by a scoop swung from a rude scaffolding, and worked by two, four, or six men. The country lies at a level generally less than 10 feet above the sea. The wells are sunk to a depth of 15 or 20 feet through the magnesian limestone, which almost everywhere underlies the soil within 2 or 3 feet of the surface; and, except for a few days in the year when heavy rain falls, they are supplied by percolation from the sea, the water being freed from salt by contact with the limestone and other mineral substances in its slow passage to the

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xvii., p. 483; vol. xxvii., p. 454; vol. xxxiii., p. 376; vol. xxxiv., p. 67; and vol. xxxv., p. 139.

wells. As may be readily supposed, wells thus filled are soon emptied; and in fact the supply is generally exhausted when a well has been drawn upon for a few hours; and from twelve to sixteen hours elapse before the supply is renewed. The mode of raising the water is by a lever, 20 to 30 feet in length, turning on an axle resting on two uprights, and having a bucket suspended by a rope or light pole from one end, which is lowered and raised by hand, the lever being weighted at the other end so as to counterbalance the filled bucket and facilitate the raising of it. When the well is deep and the lever long in proportion, the work is further aided by a man, and in some cases two men, walking backwards and forwards on the lever, so as to contribute by their weight at the two ends alternately to the rapid rise and fall of the bucket. In this way about 600 cubic feet of water may easily be raised from a single well in one hour. On an average one well is sufficient for the irrigation of an acre of garden land in the driest weather where the soil is light, and of an acre and a quarter where the soil is less absorbent. As these wells never fail, being supplied from a source which is independent of rainfall, the successful raising of two, and even three crops, in the year from the same land is as much a matter of certainty as the recurrence of the seasons.

Those parts of the country where the system of tank irrigation prevails surround the district lying within what is called the Mountain Zone, and extend to within a few miles of the coast, embracing about three-fourths of the area of the island, and having an elevation of from 20 to 100 feet above the sea. For the most part the rivers intersecting these low-lying districts are dry for ten or eleven months in the year; but in January and June, when heavy rains fall, they overflow their banks, and inundate a wide stretch of country on each side. In a few instances only was any attempt made in former times to utilise them as feeders of tanks, by throwing weirs across them in order to divert the water by canals to the desired storage ground. The general practice was to depend for the filling of each tank upon the rainfall within the limited area selected as the site for it. As the country is undulating, it affords thousands of sites where tanks could be formed by damming up the outlets of drainage basins. The early conquerors of the island, who (about five centuries before the Christian era) introduced into it the arts then known in India, recognised these natural advantages, and availed themselves of them—as did their successors for more than a thousand years—to cover the face of the country with tanks, mostly of large

size, some few forming lakes of from 20 to 50 square miles in extent, having embankments or "bunds" of 10 to 15 miles in length, and capable of irrigating tracts of land as large as Middlesex. All were constructed on the same model, made familiar by the Papers on Indian irrigation read before the Institution from time to time, an earthen embankment being made across the lower end of a drainage basin, such embankment being pitched on the upper side with rough stone, and having at one end or at both ends an overfall for the discharge of flood waters, and sluices of elaborate construction for distributing the water to the fields below.

But all these great works were destroyed in succession, perhaps soon after their construction, owing to inadequate provision in the length of the overflow, and to the difference in height between it and the bund, to meet the case of an extraordinary flood. This need not be a matter for surprise; for, even had the designers of these tanks possessed that knowledge of hydraulics which would have enabled them to adjust the length of an overflow to the discharge of a given body of water in a given time, they had no means of ascertaining the quantity to be discharged. The rain gauge was unknown to them; and it is certain that the country was then covered, as it still is, with a jungle so impenetrable that nothing more could be known than the bare fact, that by throwing an embankment across the low land between two hills of moderate elevation, a reservoir might be formed of capacity presumably large enough for the purpose intended. Only those perhaps who, like the Author, have had occasion to lay out works of this kind in such a country, can form an adequate conception of the difficulty of arriving at data sufficiently reliable for the design of such a bund and overfall as would be safe under all circumstances. There are no maps, like the ordnance maps of Great Britain, from which the area of any drainage basin can be ascertained; and the cost and labour of making a special survey for the purpose in any given case would be enormous. Then, observations of rainfall have not extended over a sufficiently long period to show what ought to be taken into account in designing works of this nature; nor have they, owing to the want of intelligent observers, been carried out in all the most desirable localities. Thus, a rainfall 10 or 12 inches in depth in one day—a thing of almost annual occurrence in some locality or another—had till lately been commonly accepted as the limit of what was probable anywhere; but in 1872 there was registered at one station a fall of 18·9 inches, and at another a fall of 17·9 inches, in twenty-four hours.

In view then of the difficulty of obtaining correct information on the two essential points of area and rainfall, it would almost seem that no work of this kind can be safe for any considerable length of time, unless the dam to retain the water be of masonry throughout, so as to form one continuous overfall from end to end; or, at least, the usual condition of things be reversed, and the length of the overfall, instead of being the smaller, be made by much the larger fraction of the whole length of the structure. The Author's impression to this effect has been strengthened by what occurred recently to several tanks of moderate size in the eastern province of the island, restored or reconstructed only a few years ago, on designs based upon calculations which were believed to be perfectly safe. In the case of one of them, which may be taken as a fair sample of all, the overfall was of extraordinary length as compared with the bund, and it was believed that not more than $2\frac{1}{2}$ feet depth of water could ever rise over it, while the top of the bund was from 6 to 7 feet above the estimated flood level. It seemed to the Author, who saw it several years ago, that the great length of the overfall afforded ample provision against all possible accidents. But in January 1878 the rainfall throughout the district was heavier than had been experienced for many years, giving rise to floods which carried away numbers of bridges and other works, and raising the level of the water in this particular tank to nearly 9 feet above the overfall, or just sufficient to overtop the bund and carry away a large portion of it.

Smaller tanks adapted for the irrigation of from 20 to 200 acres, which are most numerous in the northern and north-central provinces, and are the only structures of the kind now in use there, were formed in a much ruder manner than that followed in constructing the magnificent works which have fallen to ruin. They probably owe their existence to the small village communities, into which the population was divided on the failure and abandonment of the larger tanks, and when the country no longer possessed to any extent the skilled labour which the native kings had called into play when carrying out those immense works. In none of the hundreds of tanks which have come under the Author's observation was there, until quite lately, anything deserving to be called a work of art. The overfalls were, in most cases, merely a depression in the bund, protected sometimes by rough stone pitching, or they were scarped out of the hard ground against which the bund abutted; while the sluices were formed of undressed blocks or slabs of stone, and often merely of rough timber, without any better means of stopping

the flow of water through them than a gate of wattles banked up with turf, which the cultivators removed when they desired to let the water through. That structures so rude should have lasted through so many ages, can be due only to the ease with which any damage to them might be made good by the villagers. But neglect on their part has so often led to damage beyond their power to repair, resulting in the stoppage of cultivation for two or three years in succession, that the Government, in the interests of the people as well as of the revenue, felt bound to step in by legislation which placed the management of these tanks, and of small irrigation works generally, on a proper footing, and removed all excuse for that neglect into which they were gradually falling. Under this improved system, small works of restoration and repair are now carried out in all parts of the country, with skilled labour employed under Government supervision, and with a happier result than would probably have followed the realisation of those grand schemes, so often proposed, of restoring the larger works abandoned centuries ago, to bring which into operation would necessitate the introduction of a new population.

Of the exceptional class of works already alluded to, where the design was to dam up the water of a river and divert it by a channel to a tank, the most remarkable is the Giant's tank, in the northern province, of the date of construction of which there is not even a tradition. In this case, the mistake committed was more unaccountable than that which caused the destruction of the ancient tanks; for the nature of the country in which it is situated must have been easy to study, being a dead flat and generally open, the soil being incapable of supporting the luxuriant growth of jungle which renders other districts so difficult to explore. The dam, or "anicut," across the river was formed of large rectangular blocks of roughly-dressed stone, so well put together that it is still in as good order as when it left the masons' hands. The tank on the right bank of the river, some few miles below the anicut, formed by an earthen bund several miles in length, but nowhere more than about 10 feet high, was nearly completed, and a similar tank on the opposite bank in part constructed, before it was discovered that the bed of each was at too high a level for the water to reach it; and that both tanks, even had it been possible to fill them, must have been so shallow, that evaporation would not have left in them a month's supply of water for the area designed to be irrigated.

In the district of Karetchi, near the neck of the Jaffna Peninsula, the rice fields lie in several large patches on each side of one of those

rivers which flow only at intervals when there is heavy rain. Like the fields in the peninsula, they are mainly dependent upon the direct rainfall, and upon the ponds which lie scattered amongst them. Although it was ascertained, by a survey which the Author made in 1858, that a tank sufficiently large to irrigate them abundantly might easily be formed a few miles higher up, it was not considered that the work would be remunerative, in view of the cheap rate at which rice could be imported from India; and the project of carrying out the work was therefore abandoned. But the people endeavour to supplement the scanty supply of water derived from the rains, by throwing out temporary groynes of timber and earth from each bank of the river just before an expected flood, to divert a portion of the flood waters by channels leading directly to their fields. When the floods are moderate these groynes do good service for a few weeks; but as often as not they are carried away. To check the tendency to erosion, by diminishing the velocity of water in them, the channels are made so tortuous, that their actual length is more than double what they would be if straight, and they are otherwise so badly formed that much of the small supply of water yielded by the river is wasted.

The third method of obtaining water for irrigation is practised in the mountainous districts by tapping the streams. The fields are numerous, but nowhere so extensive as those commonly met with in the low country. For the largest of them a channel 6 feet wide and about 2 feet deep, conveys all the water necessary for thorough irrigation; and to divert along it as much water as may be required, nothing more is needed, in most cases, than to throw a few boulders into the stream just below the point from which the channel commences. In those few cases where, during dry weather, it is necessary to prevent any waste of the water brought down by the stream, there are properly-constructed stone dams with regulating sluices. The channels are scarped out of the hillside, following the contour of the ground, and for a short distance after leaving the stream they are protected by a low wall on one side, which acts as an overfall whenever an undue quantity of water is discharged into them, as happens when the rains swell each stream into a torrent.

None of the irrigation channels in Ceylon are large enough to be used for inland navigation; and for this reason they have been everywhere laid out with as great a rate of fall as is consistent with a view to safety against silting. For the most part their inclination gives a velocity of water of from 2 to 3 feet per second; but even where the velocity reaches 4 feet per second, as

it often does, there is no appreciable erosion of the sides or bed. Much of course depends upon the character of the soil through which the channel may be cut. But, so far as the Author's experience goes, the lightest soil will bear a velocity of 2 feet per second, where the sides of the channel have a slope of 2 to 1; while in stiff clay soils, a slope of even 1 to 1 is ample in the most rapid of these channels. Such an assertion may, no doubt, appear inconsistent with what is commonly set down in printed rules and tables as to the moving power of water at given velocities; but these rules, however valuable as a general guide, are based upon experiments tried under conditions which never, or but rarely, prevail in actual practice. The Author has generally found that silting (in the case of channels cut on a contour line in sidelong ground) is due, not to the diminished velocity of the stream, but to the surface drainage from the land on the upper side of the channel. Yet even here the close vegetation above is usually sufficient to prevent the surface soil from being carried into the channel; and in the worst conceivable case, where the land above is bare and the soil loose, a catchwater drain above the channel, with frequent outlets under it, would be an effectual protection.

In no case has the Author found any tendency to the excessive growth of weeds in channels having an appreciable fall. It is in canals intended for navigation only, and where there is no current, that he has experienced any trouble in keeping down such vegetation; and a little attention on the part of the native overseers is sufficient for this. A small force of men is usually kept on a line of canal to prevent cattle from injuring the banks; and these men are provided with rakes, by which the weeds can be torn up and drawn to the banks as fast as they appear. Moreover, it is only in shallow canals used for flat-bottomed boats, where the depth of water never exceeds 4 feet in dry weather, that weeds are likely to spring up to any extent; and in these men can easily wade while working the rakes, if the canal be too wide for the weeds to be reached from the bank. The experiment of attaching large rakes to the stern of a boat drawn along a canal, in the hope of economising labour by a wholesale system of weeding, had a fair trial; but the primitive method of raking by hand was found to be as efficient, and much more economical.

The Author regrets that he cannot give any details of cost of the various irrigation works undertaken in Ceylon in recent times. Such details would be of little interest, except in connection with a statement of results as to the quantity of water made avail-

able, and the extent of land brought under tillage in each case; and trustworthy information on these points is not procurable. Enough is known, however, to prove that in Ceylon generally, and especially in the unhealthy districts, where tank irrigation is chiefly carried on, the high price of labour must always render new works too costly to be commercially profitable. For this reason attention has of late years been confined to the improvement and restoration of small works long existing, but which had either been badly constructed originally, or had been suffered to fall into neglect, and where the cost of restoration, though often great for the small amount of work done, is trifling in comparison with the benefit obtained. By the outlay incurred, lands which had for many years lain fallow are now brought under cultivation; and the cultivators are no longer dependent for food upon imported grain, the price of which, however low at the sea ports, is increased enormously by transport to the interior.