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Irrigation in the United States: Its Geographical and Economical Results: Discussion

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semi-arid states. This is the wheat from which macaroni is made, and the acreage devoted to its cultivation is increasing so rapidly that the hopeful American expects before long to be shipping macaroni to Italy.

A hardy Swedish oat capable of resisting a great amount of drought has been established in Montana, the Dakotas, and neighbouring districts, and is giving excellent yields.

The Vladimir cherry and forms of the Siberian crab-apple have been brought from Siberia, and introduced into the cold regions of the north-west.

Alfalfa is another of the successful immigrants. Varieties have been found that withstand the rigorous winters of the north-western prairie states; other varieties have been found in the alkali districts of Algeria and Turkestan, and these are being cultivated in similar districts in the south-west, and it is expected that large areas now useless on account of excess alkali will be reclaimed.

For the fertile oases that irrigation is creating in the lower Colorado desert, many things are being imported. Berseem, a variety of clover, from Egypt, the fig-tree from Smyrna, and many varieties of date palm from Egypt and from the oasis of Biskra, in Sahara. A species of alfalfa has been found which, on these rich slopes, yields six or seven crops in the course of the year, aggregating from 10 to 15 tons per acre.

Much of this "Great American Desert" is to be reclaimed, but it is not by irrigation alone that this will be brought about, but by the introduction of hardy plants that have proven themselves able to hold their own against the desert in other parts of the world, and by the careful breeding and nourishing of these plants so that they will be able to do even more in America than they have done elsewhere.

Not many years ago much of this vast region was a grazing-ground for millions of buffalo, deer, and antelope, and a hunting-ground for those wild children of the plain—the Indians; but the white man came, the ambitious white man, and in a little while nearly all forms of the old animal life had disappeared. They were succeeded by a creature a little less wild and a little less attractive, but still attractive, the cowboy; and now he is almost extinct, and is being supplanted by that very tame and very prosaic individual, the man with the hoe. Those of us who had the good fortune to see something of that freer and wilder and more generous life of the plains before the advent of the irrigating ditch, find in the recent and prospective changes much to be regretted. But, on the other hand, much has been gained; the productivity of tillable areas has been greatly increased; desert stretches have been converted into fields of waving grain, and millions have been added to the taxable wealth of the nation. In view of all this, I think we should be content.

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Before the paper, the PRESIDENT: I have to introduce to you to-night the reader of the paper, Major Beacom, who is military attaché to the United States embassy.

Our Society has always maintained close relations with both the naval and military members of that embassy, which has been fortunate in obtaining a succession of able men to fill those posts. Major Beacom has had the advantage—a great advantage to all geographers—of seeing active service outside his own country in the Philippines, and he has always taken a great interest in this question of irrigation. He will give you to night what I know to be a most interesting account of the effects produced by irrigation on those arid regions of the Western United States, which were in former days regarded as irreclaimable deserts. The subject is one of high interest to all geographers, but it is, I think, of special interest to us, because it is a question which largely affects the future of considerable portions of the British Empire. An immense work in this direction has been done, as we all know, in India, which fortunately possesses a government independent of the struggles of parties, and so has been able to conduct its work efficiently. Much has also been done in Australia, where our colonial brothers are free from the fetters of mediæval modes of thought. So again, as we all know, the ancient irrigation of Egypt has been vastly extended under the wise autocracy of Lord Cromer. But there is one part of the British Empire where not only the economic future, but also the political future, depends largely on the thoroughness with which a policy of irrigation is carried out. I am referring, of course, to the new colonies of the Transvaal and the Orange River Colony, to which must be added a considerable portion of Cape Colony. Our own rulers at home have not carried out any very lasting or consistent policy with regard to this matter, and this is not surprising when one considers the feeling of almost disdain that so many people in this country, otherwise highly educated, have for geography; for I need not point out to you that irrigation over vast regions is strictly a geographical question, depending as it does upon the morphology of the country, on the political conditions, and on the nature of the soil. I think that it will be very agreeable to hear a paper on this subject delivered by a citizen of a very go-ahead and progressive country, in which geography is considered to be a proper subject for the education of youth. I will now call upon Major Beacom to read his paper.

After the paper, the PRESIDENT: I think we must open the discussion by calling upon Sir Colin Scott-Moncrieff to say a few words. He is, as you know, not only the highest authority in India, but the highest authority in Europe on the question of irrigation in many parts of the world.

Sir COLIN SCOTT-MONCRIEFF: May I be allowed first to say what pleasure I have in welcoming a brother officer from the American corps of Engineers in this country? I am sure my brother Engineers present will join me in saying so. Major Beacom has given us a most interesting lecture. One little thing he remarked was curiously unlike my own experience: he said parts of the Colorado had reminded him of the Nile in Egypt. Now, it struck me the whole position was as unlike the Nile as anything I had ever seen, not only as regards the country, but among the *genus homo* to whom he alluded. As I listened to page after page with great interest, I kept asking myself questions which I would like to ask the lecturer; but if I asked them all it would keep you here at least till midnight. He told us a great deal; but he knows, as well as any one else, that there was a great deal he had not time to tell us. I would like to ask where all this great water-supply comes from; whether it is a certain supply or not; whether in that country they have great famines owing to drought, such as we have in India; and whether they raise grain at all without irrigation? In Egypt there is no halfway house; there is merely irrigation or the desert. Major Beacom alluded to the small area of land that was irrigated in Egypt; but it is all there is of Egypt—there is no land there that is not irrigated. The country of Egypt is about one and a half

times the size of Wales. It would take eight Egypts to make Great Britain, and out of that you cannot make a large field for irrigation. When I talk about Egypt I do not mean the desert on the two sides, because they are no more Egypt than the sea is. In Egypt everything is grown by irrigation, because there is practically no rainfall to speak of. Therefore, you cannot have famines from want of rain, and there is no famine so long as the Nile is properly managed. In India it is very, very different. There is a certain amount of rainfall, which is all that a great part of the country has to depend upon; and it is sufficient for the commoner style of crops, but not for the more valuable ones. And there irrigation comes in; and then the question comes, How much water is there, and can you count upon it? In Northern India there is a great ice-wall, and the hotter the day the more the melted ice comes down, rolling over the country. Further south there are large reservoirs, great lakes doing valuable work; but when the rains fall, as they sometimes do, these lakes are empty. I remember having experience of it in 1877, in a beautiful fertile province, Mysore, where the reservoirs number some 30,000, I believe, and there was not a drop of rain in one of them. I do not know if in America that kind of thing can happen; whether the rivers ever fall short of water, or whether there is a constant supply. Reservoirs go a long way, but any scheme of irrigation requires a large volume of water. You will be perhaps surprised to hear that a million cubic feet of water will not keep more than about 7 acres of rice alive. One great point we always have to consider with regard to an irrigation officer in India, is what use he makes of his water. An officer is put in charge of a certain amount of water, and he is asked, "How many acres have you irrigated out of it?" He keeps an exact account of the volume of water that enters and the quantity that leaves his division, and he has to send in an account showing that so many cubic feet of water have irrigated so much land. I do not know whether it has come to that, or whether there is the necessity for it, in America. If there is plenty of water, there is no great need to trouble about it. Major Beacom alluded to the large area—45,000,000 of acres—in British India. I should say that of that 45,000,000, 13,000,000 are irrigated from wells. These wells are made by the private farmers and peasants; they are often merely holes cut in the ground down to the spring-level. Sometimes—not in most cases—they are lined with masonry. The Government has nothing to do with them, but it gives a man an advance to help him to dig a well, and it is afterwards entirely his own; and for this irrigation the Government can take no credit. What has been done by Government is not much more than 30,000,000 acres. I believe there is going to be a great deal more. I was struck, but not more than I expected to be, with the courage and with the magnificent engineering works of the American engineers. The difficulties they have had to face were enormous, and the works are evidently of a very high order. One would like to hear a great deal more about them, and, of course, most of all to visit them. One great difficulty that exists in India is the soil. A large portion of the country is composed of what is known as "black cotton soil;" it is very clayey, and a very small amount of rain will produce a crop. Very much rain will make a quagmire, and you can get nothing much out of it; but with moderate rain it is especially good for cotton. My chief business in India for many years was considering the question of irrigation always from the point of view of the prevention of famine, and, coming to a district of black cotton soil, the people would come and say, "For Heaven's sake, don't send your water here." And that would go on for perhaps ten years, and then they would come and go down on their knees, and say, "For goodness' sake, give us water." The difficulty is the financial question, because if people only want water once in ten years, you cannot see how to charge them. My experience of

irrigation has always been with subject people, either the natives of India or the natives of Egypt, and they at least are totally unlike the natives of America. With these subject people there is a strong Government, and you lay down rules which the people must obey. For instance, a distributing channel delivers water to the first 3 miles on Monday, Tuesday, and Wednesday, and to the next 6 miles on the other half of the week. The irrigator has a little earthen pipe inside the channel from which he draws his water, and if he is caught irrigating his crop on one of the days on which it ought not to be irrigated, he is fined; and this law they can keep pretty well enforced. I do not know that the American farmer would be as amenable to reason if he saw his crop dying? I do not want to say anything against Boer farmers, but from what one has read, I do not think they are very good at obeying the law. The conditions with regard to water in the Transvaal are very curious. It is a limestone formation, and there seems to be a regular network of rivers or branches of rivers some 40 or 50 feet below the ground. A farmer sinks a well, starts a pump, and he may pump dry a dozen farms all round him. While he is injuring the neighbours, he may have far more water than he wants for himself; but he says, "I bored the well, and I am entitled to all the water." Laws must be made for such cases as this, and these laws must be rigorously enforced. The most law-abiding and the most scientific irrigators I know are in North Italy; they have had irrigation from the time of Leonardo da Vinci. They have a beautiful system of canals, and there the farmers are law-abiding; and I have been told it is considered as disgraceful to take water out of your turn as to steal a horse out of a stable. I hope it may be the same in America. I was much interested in the efforts that are being made in America to study agriculture and see what is best for the different soils. I am sorry to say we are very much behindhand in that respect, both in India and in Egypt. The total initial cost of these American projects, we are told by Major Beacom, is from £4 to £17 per acre. In India the average is about £3 5s. per acre, but there are no works like these tremendous works we have seen photographs of to-night.

THE PRESIDENT: I will now call upon Prof. Gregory, who, during his long experience in Australia, must have gained a great deal of information connected with the irrigation there.

Prof. GREGORY: I should like to join Sir Colin Scott-Moncrieff in expressing the high appreciation in which the work of the Irrigation Department of the United States is held in other countries. The great collection of data obtained by that department, not only throws light on many problems of high theoretical interest, but is of great practical value to those who in other countries are wrestling with drought, and trying to stay the deplorable waste of water in times of flood. We must thank Major Beacom for his interesting account of the work at present in progress in the United States. It is interesting to observe in how many respects Australia and America are developing their irrigation schemes on parallel lines; sometimes the one state and sometimes the other is the pioneer. The United States is, of course, working on much greater lines; but its Reclamation Act, providing for great national schemes, conducted by a branch of the Geological Survey of the United States, follows the much earlier example of Victoria, where the great reservoirs and long water-channels are all State works, made and managed by a branch of the Mines Department. So far as Australian practice is concerned, there seem to be three main requirements in successful irrigation: the water is wanted at the right season, and, as Sir Colin Scott-Moncrieff pointed out, a great deal of it is wanted; the population should be concentrated, at least locally; and there must be a considerable population of painstaking and careful farmers. Irrigation work has the great advantage that a desert soil is, in most cases, a fertile soil. There are, of

course, exceptions; but in the majority of cases the old desert soils have stored up such accumulations of plant food that they only want water to grow luxuriant crops. The Milk river controversy is analogous to that between three Australian states over the Murray. South Australia contributes nothing to the waters of the Murray river, all of which comes from New South Wales and Victoria. Canada may get some encouragement from the Australian decision, as the two states that supply the water agree to allow South Australia a very considerable share of it.

The PRESIDENT: I will ask Mr. Colquhoun if he will say a few words. He is an old South African, and knows large parts of the world.

Mr. COLQUHOUN: The subject of the paper read this evening is one that is of special interest to myself, although I have not had the opportunity of personally visiting these irrigation works of which Major Beacom has given us so interesting an account. There is, perhaps, no more eloquent tribute to the energy and enterprise of the American people than these irrigation works, and it is wonderful to-day to realize that the enormous areas of land, which not very many years ago were wild and almost trackless, are now so fully peopled and so far developed, that it is necessary to begin the undertaking of these reclamation schemes with a view to intensive cultivation later on. The special point to which I venture to call your attention this evening, is one which came under my notice in South Africa in connection with this question of irrigation. Major Beacom has incidentally referred to the great difficulties that arise from the existence of water rights in old countries; but he has not said so very much on this particular subject, because in new regions, such as the one he has been treating of, these difficulties are not accentuated in the same way as they are in the older and more peopled countries. In Italy, as Sir Colin Scott-Moncrieff has partly indicated, this particular difficulty (which was very acute indeed, arising from the conflicting interests of that country) was met by what may be briefly called the nationalization of the water rights, and, in the opinion of many people who know South Africa, it will be necessary for that country to follow the example of Italy, if the full possibilities of South Africa as an agricultural country are ever to be realized. The United States are to be congratulated on having such a wonderful organization—an organization which combines so complete a scientific study with the practical enterprise which the American people always exhibit. We ourselves in India have a department, as our chairman has told us this evening, which has done not only such wonders for India, but has helped to recreate Egypt, and has sent most distinguished irrigation engineers to nearly all parts of the world to report upon that subject, and Sir Colin Scott-Moncrieff, who is with us this evening, is perhaps the most distinguished of these engineers. But there are two countries within the British Empire, one South Africa, and the other Australia: South Africa, which has hardly begun to think of irrigation; Australia, which has done something, but by no means what ought to have been done for that great country—these two seem still not to realize the value of really scientific irrigation. It is, therefore, of the greatest value to us, and fraught with interest also, to hear of the methods which are being adopted in the United States, where scientific study is so happily combined with practical energy and enterprise. And I hope that our young democracies overseas, those within the British Empire, may see their way to follow the example of our American cousins in this respect, if not perhaps in all others.

Mr. BUCKLEY: At this late hour I feel I must not detain you long, but I should like, in concert with Sir Colin Scott-Moncrieff, to congratulate Major Beacom and the Engineers of America on the great progress they are making in the science to which so many of us in India have devoted our lives. Major Beacom referred to the great Colorado river, and there is one point in connection with that which may be of some

interest to the meeting. The great Colorado river carries down, Major Beacom told us, 1,500,000 tons of silt every day in a great flood. Now, perhaps you will all think that this mud in the water is not a very important matter. I assure you that it is important. In India it is a common thing to see a cultivator, who has got his ricefield filled up by the rain, deliberately letting off the rain-water, and then, when the field is dry, allowing the canal water to flow over it again. You ask him why he does it. He tells you it is because he gets fertilizing silt from the water. It is the fertilizing silt which has made Egypt so fertile, and it is fertilizing silt which will keep the Colorado claims productive. I heard the other day that a large number of American farmers were leaving America and going to Canada. I asked why it was, and I was told they were leaving America because their lands were becoming exhausted, and they were going to the virgin soil of Canada, where they could grow the good crops they used to get in America. Now, if the lands under irrigation in Colorado are to be productive, you must do the best you can to transfer the silt from the river on to the lands. Major Beacom said he was not aware what the volume of silt was that passed down the Nile. I happen to know the figures. Sir William Wilcox gives the proportion of silt in the river, and I find that about the same quantity of silt passes down the Nile in a big flood as comes down the Colorado; that is, the maximum of any day of the year is about the same, but the Colorado carries rather more than the Nile.

The total quantity of silt which passes down the Nile during a whole year is given by Sir William Wilcox in his book as 47,000,000 cubic yards. I dare say these figures convey to you very little impression of the volume. You know Hyde Park and Kensington Gardens. The houses all round them are about 50 feet high. Now, suppose you filled the whole of Hyde Park and Kensington Gardens up to the top of the present houses with mud from the Nile, and then, on the top of the present houses you built another lot of houses 50 feet high, and still a third lot of houses 50 feet high on the top of the second lot, and then filled up the whole area to the top of the third set of houses, the quantity you would absorb would be about the volume of mud which comes down the Nile in a year. A large portion of this silt is spread over the land in Egypt, and it is to that that the land owes its fertility. I feel a little doubt whether, if these irrigated lands in Colorado have to depend largely upon reservoirs, they will retain their fertility; for, mark you, when you put water into a reservoir and keep it there a long time, all the fertilizing matter which ought to go on to the land, or a very large proportion of it, sinks to the bottom of the reservoir; you do not get it on your fields, and you choke your reservoirs with it. I think the American Engineers will have to consider whether some measures are not necessary to enable them to pass the silt which the Colorado river carries on to the lands, so that they may keep them up to their present standard of fertility. There are other points to which I should like to refer, but I feel I should not detain you longer. I will, therefore, only thank you for your kind attention.

Colonel CHURCH: In answer to the gentleman who has just spoken, may I say a word with reference to the silt question. The engineers of Canada tell me that there are 70,000,000 of acres of arid and semi-arid lands which can be irrigated there. If it is necessary to have silt to fertilize, for instance, a wheat-field, why is it that the further you go north the more bushels of wheat you get to the acre of land which is not irrigated? The reason is, that up to the limit of the wheat belt, the ground freezes to a depth of at least 5 or 6 feet. When the wheat begins to spring above the ground it is in the warm weather, when evaporation is constantly taking place, in a very gentle way, from that great ice-cap that underlies the soil. There is no silt in it. It is about the purest water you can get, and yet it will give you twenty-two bushels of wheat to the acre, while if you go south, to the border of

the United States, you get from eleven to thirteen bushels. Therefore, although the silt may be very useful, clear water may also be desirable. I may say that the largest and most beautifully irrigated field I ever saw in my life was in Northern Mexico, which was irrigated by a perfectly clear-water stream. It was growing Indian corn 10 and 11 feet high, with ears of maize nearly as big as my forearm. Is the silt question the main one in irrigation?

I may say something about my favourite Spanish-American country. If you follow that great arid region of the western United States (with its sixteen states) further south, on to the Mexican plateau, varying in elevation from 3000 to 4000 feet in the north to 7500 feet at the city of Mexico, you get a vast area which can be made into a garden wherever you can find water to put upon it, and the chances are that, in nine cases out of ten, if you get any river at all, it will be a clear-water one; and, as a general rule, wherever you see irrigation there, as I have seen it extensively, you will find it is from clear water. If you go still further south, to the tableland of the Andes, and their western slope, I can point there to the remains of irrigation works so extensive that it amuses me to hear about modern irrigation, and of the 5,500,000 acres of Egypt and the 9,000,000 of acres which, perhaps, were irrigated in the palmy days of the Chaldean empire! The ancient Peruvians also irrigated by the millions of acres, and you will find in Peru and Bolivia works absolutely tunneling the shoulders of the mountains. There are on the western slopes of the Andes sixty torrential clear-water streams which can be impounded and utilized as they were in the time of the Incas, and 50,000,000 of acres of land awaiting irrigation. The Peruvian engineers estimate that, even in a moderate way, they might irrigate  $3\frac{1}{2}$  millions of acres in Peru alone. When it rains there, as it does once in a long period of years, it is perfectly wonderful to see one of the coast deserts. In the course of a day or two it becomes a vast garden of flowers, great numbers of which are of unknown species, a vegetation which is absolutely marvellous in its appearance, a simile from Pleistocene times. And the next day you look, and it is gone; the arid region has reclaimed it again, and the rains, which have not carried a particle of silt, have disappeared.

The PRESIDENT: Unless any one else wishes to take part in the discussion, I am sure you will join with me in a very hearty vote of thanks to Major Beacom for coming here and giving us such an interesting address, and helping us to pass a very instructive evening.

Major BEACOM, in responding, said: I wish to assure my audience, in the beginning, that I shall not attempt to answer the many questions that have been asked, as that would take too much of your time, but I shall try and answer a few of them.

As to the amount of water in the arid states available for irrigation purposes, I would say that it is not sufficient for more than a small part of the vast region that would be benefited by irrigation; but it is proposed to make the most of existing supplies by increased economy in the use of water, and also to increase the supply, or at least to secure a steadier stream-flow, by preserving the forests on the headwaters of irrigation streams. The Government forest reserves now cover an area about equal to that of the British Isles.

Some exception has been taken to my comparison between the Nile and the Colorado, but I still think that the conditions, from an irrigation point of view, in the lower Colorado and the lower Nile are very much alike. The analysis of the soils shows them to be almost identical, and in the matter of rainfall and temperature there is very little difference. The proof of this similarity of conditions is found in the fact that most things that grow in Egypt can be grown as well in the lower Colorado.

I am not prepared to answer the question, "How are you going to train your



people to wait patiently for much-needed water until their neighbours' crops have been watered, as is often necessary?" We know that there are many difficulties in the way, and we have already sent experts over the world to study the systems of management found workable in other countries. We have concluded that there is nothing to be learned from India or Egypt, because the social and economic conditions in those countries are totally different from our own, but we hope to profit from the experience of the communities of Northern Italy, where the conditions are more like those in America. We are just making a beginning.

I would say, in conclusion, as it may be of interest to you to know, that President Roosevelt did much to secure the passage of the Reclamation Act—so much, indeed, that he may properly be considered the author of that important law.

## A NEW ISLAND IN THE BAY OF BENGAL.\*

By Lieut. E. J. HEADLAM, R.I.M. Survey of India.

HOPING that it may be of interest, I beg herewith to send a sketch, with a couple of plans and some photographs, together with this short account of a new island which was thrown up by the action of a mud volcano, in the Bay of Bengal, off the north-west corner of Cheduba island, on the Arakau coast of Burma, December 15, 1906.

The island is situated in lat.  $19^{\circ} 0' 6''$  N., long.  $93^{\circ} 24' 20''$  E., and is  $8\frac{3}{4}$  miles in a north-west by north direction from the north-westernmost point of Cheduba island. It is in extent 307 yards long in its greatest length running south-south-west and north-north-east, and is 217 yards at its greatest breadth running in a north-west and south-easterly direction; the highest point is 19 feet above high-water mark, and it is entirely composed of mud, with a small quantity of stones of various sorts, but no lava.

On December 15, 1906, the workmen employed by the Public Works Department of Burma in constructing a lighthouse on Beacon island (which lies south-east by south about  $4\frac{1}{2}$  miles from the new island) heard loud rumblings and rushing noises, and noticed that the sea was in a much disturbed condition to the north-westward; finally they saw a mass of land appear above the water. This, according to their account, twice disappeared and reappeared again; but this was probably only an optical illusion owing to the wave which was caused by the great displacement of water, which rose several feet above the normal, and probably washed almost over the island.

On December 20, on receiving the information from Mr. Dawson of the P.W.D., who had been on Beacon island, Colonel Huddleston, R.I.M. port officer of Akyab, visited the island, and found it still very soft and hot, but not in any way active. On December 30 the R.I.M.S. *Investigator*, under the command of Commander W. G. Beauchamp, R.I.M.

\* Research Department, February, 1907. The discussion on this paper will be published with that on Mr. Sivewright's paper on the "Cutch and the Ran," which was read at the same time.