REPORT

ON

Irrigation in South Africa

BY

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My Lord,

Having received directions from Your Lordship to proceed to South Africa and examine the irrigation possibilities of Cape Colony, the Orange River Colony, and the Transvaal, I have the honour to report that I have completed my mission and now submit my report.

Aided by the Hon. Dr. Smartt, Commissioner of Public Works for Cape Colony; His Excellency Major Gold-Adams, Administrator of the Orange River Colony; His Honour, Mr. Sloley, Commissioner of Basutoland; and all the officers under their authority; and by the Military Authorities in South Africa, I have been able to inspect typical localities in the three Colonies and to learn the views of many of the best informed agriculturists in South Africa. To all who have aided me I here tender my best thanks.

Having carefully read all the literature on the subject of irrigation which I have been able to obtain, and having consulted the very best authorities, at the very outset of my report I wish to draw Your Lordship's attention to the foundation stone on which alone can be built the permanent prosperity of South Africa. As Administrator of the recently acquired Crown Colonies of the Orange River and Transvaal, Your Lordship is in a position to confer a benefit on South Africa such as has fallen to the lot of few men. Apart from the development of its gold, diamond, and coal mines, South Africa has remained strangely stationary. Fifty years ago it was a pastoral country importing cereals and dairy produce and even hay from foreign countries. It is the same to-day. Half a century ago it needed a farm of 5,000 acres to keep a family in decent comfort; to-day it needs the same farm of 5,000 acres to keep a single family in comfort. Except in the extreme South-Western corner of Cape Colony, agriculture has scarcely been attempted, except on the most primitive lines, and on the most insignificant areas. Farmers to-day trek from the high veld to the low veld and back again with the seasons, just as the wandering Arabs of the desert have done for centuries. The reason for this want of development of the agricultural wealth of the country, and the consequent acute stage of the poor white question, lies in the fact that the rainfall of the three Colonies, with the exception of the extreme South-West corner, is not only erratic and uncertain at the times most opportune for sowing, but is constant and heavy in autumn. Autumn again is quickly followed by a very severe and frosty winter without a particle of moisture in the air. When rain is wanted it is generally not there, when it is not wanted it is invariably
present. For countries situated the only possible means of development lie in the storage of water when it is present and not needed, and its utilisation by irrigation when it is needed. Agriculture without irrigation is generally impossible in the Northern Colonies. In the face of such a state of affairs, the irrigation laws of the three Colonies framed by Englishmen and Dutchmen who came from wet and foggy countries, and who considered the accumulation and storage of water as public nuisances, and the transfer of water from one valley to another as a public evil. If these countries are ever to develop the immense agricultural wealth which is to-day buried many thousands of feet below impenetrable strata of unwise and unprofitable legislation, the first move must be to proclaim the countries themselves as arid or semi-arid regions, and legislate accordingly. The whole of South Africa from one end to the other is looking to Your Lordship to take the first step in the two Crown Colonies which you administer. The moment Your Lordship takes action, the self-governing Colonies of the Cape and Natal must follow suit or take an inferior position.

When Victor Emmanuel consolidated Italy into one country, he decreed at the outset of his reign that the whole of the rivers and torrents of Italy were part of the public domain, and, as such, the property of the Government representing the people. 'Old irrigation rights of thousands of years' standing stood in the way of such legislation, but the Government of Count Cavour possessed a strong hand. Having decreed the rivers and torrents as public property, the Government in the same bold and decisive manner defined with great accuracy all the indefinable and vague claims of centuries, and then set itself to legislate for future conditions. Italy owes much of its prosperity to this wise and accurate legislation. The irrigation laws of Italy are given in great detail by Mr. W. Hahn-Hall, in his book "Irrigation development, France, Italy, and Spain." There Italian irrigation laws, in great part developed by the ancient Romans, might be taken as a model for all arid and semi-arid countries in the possession of Europeans. It is laws such as these that vast tracts in India and the whole of Egypt owe all their prosperity. And it is to legislation such as this that all thoughtful men in South Africa are looking forward, confident that the Nation possesses in Your Lordship a man qualified in every way to take his stand by the measures of the type of Cavour.

Important irrigation works should be carried out by the State.

So far I have written without any hesitancy whatever. The next point to which I have to draw Your Lordship's attention is one on which different opinions have been held in the past, but on which there is to-day a great convergence to one point of view. In many countries statesmen have considered that irrigation works should be left to individuals and concessionnaire companies. Such works, when of any magnitude, have been, as a rule, capricious failures in the hands of companies, which have been inimical to realise profits and which have in consequence forced their engineers to overrate their reservoirs and canals in their early and undeveloped stages. With works carried out by States, the results have, on the contrary, been decidedly encouraging. Canals, which in the early years have not paid their working expenses, have gradually paid their interest charges, and in the course of seven and eight years have paid profits of 5 and 6 per cent on many millions of capital, even when the capital accounts have been swelled by all the interest charges during the early years of loss and slow development. Having served for twelve years in the Indian Irrigation Department, where the Government has spent £30,000,000 on Irrigation Works, and is on the eve of spending as much again, and having served for eighteen years in Egypt, where Lord Cromer's Government has carried out Irrigation Works which can only be approached in magnitude by the great works of the Twelfth Dynasty Pharaohs, I naturally consider the Government should carry out in an arid or semi-arid country. Not only do well-conceived and well-executed irrigation works bring in a direct benefit to the State if allowed to develop on slow and natural lines, but they also bring benefits which a State range from increased wealth of every kind. If this is the case in ordinary countries, much more is it the case in a country where we have special difficulties, which, I think, can be solved by irrigation alone.

In many countries, where the extension and amendment of the arable land provide outlets for the ever increasing population, the poor white with its pastoral population. This acute has been aggravated in manual labour demanding when carried on in competition with black labour. Parentage. Many Englishmen in the Colonial ranks are poor whites of more acute than ever. Fortunately there is one kind of manual labour. While the country is given up to stock-farming, the poor white settlements allow him to exercise them. It, however, the Government were to carry and then to take up along the canals such works as were suitable for agricultural, the land with occupancy rights. Such tenants would pay a fixed rent to the Government, and the owner of the lands they occupied, for their rents could sale or otherwise. In this way the agricultural holdings would not be hindered by the conversion of a desert to a condi-
tion of profitable productiveness, is the work of time, which cannot be begun
until the irrigation works are actually completed, and when begun is slow of
full development. Meanwhile, however, the interest account accumulates, and
often in cases of large amounts of revenue as to bring discouragement, and
“sometimes actual bankruptcy, before a paying basis is reached. That storage
reservoirs are a necessary and indispensable adjunct to irrigation development,
as well as to the utilisation of power, requires no argument to prove. That
“they will become more and more necessary to our Western civilisation is
“equally sure and certain; but the signs of the times seem to point in the
“inevitable necessity of governmental control in their construction, ownership
“and administration.” If private enterprise cannot succeed in irrigation works
of magnitude in America, it will surely not succeed in any other country in
this world.

I have so far drawn Your Lordship’s attention to the difficulties which
lie in the way of the successful prosecution of large irrigation schemes by con-
cessionaire companies, which are eager for quick returns. There is one side,
however, of the question, which in a country like the Transvaal, should not be
lost sight of. The mineral wealth of the Transvaal is extraordinarily great,
but it is exhaustible. Some say within a space of fifty years, others within a
space of 100 years. It would be a waste indeed for the country if some of
this wealth were devoted to the development of its agriculture. Agricultural
development is slow but it is permanent and knows of no exhaustion. If the
companies working the gold, coal, and diamond mines were by decree compelled
to devote a percentage of their gains to the execution of irrigation works on
lines bid down by the Government, they would assist in the permanent develop-
ment of the country and would be investing in works which, though slow to give a
remuneration, would, at any rate, be absolutely permanent. It would thus happen
that when the mineral wealth of the country had disappeared, its agricultural
wealth would have been put on such a solid basis, that the country would not have
to fall from the height of prosperity to the depth of poverty. This view of the
question is so important that I cannot but draw Your Lordship’s attention to it,
especially as it will be abundantly evident from all that I am going to say
that the permanent development of the agriculture of South Africa will depend
on irrigation and on irrigation alone.

Before proceeding to the detailed report on the irrigation prospects of
the different sections of the Colonies, I should like to draw Your Lord-
ship’s attention to one point of less importance certainly than the questions
hitherto handled, but still of sufficient consequence to be brought to Your
Lordship’s special notice. This point is the Metric System of Weights
and Measures. No reasoning man to-day disputes the superiority of the Metric
System to all other systems. In no direction is this superiority more pro-
nounced than in that of hydraulic engineering. To convert 9 inches of rainfall
over 35 square miles of area into cubic feet is an operation as tedious as it is
unnecessary. To convert 9 centimetres of rainfall over 35 square kilometres
into cubic metres is an operation which a child could perform in a minute. A
cubic foot of water weighs 62.4 lbs., and the calculation of the area of
fields of water weighing 62.4 lbs. with a lock gate 40 feet wide, would be an
operation demanding time and exact calculation. A cubic metre of water
weighs exactly one ton or 1,000 kilograms, and the calculation of the pres-

care of three metres head of water on a section of a lock gate 12 metres wide
and 3 metres high can be performed in ten seconds. I personally do all my
work in the metric system and consider it impossible to use the old system of
conversion tables into the ordinary English measures for the sake of those who are ignorant of
the Metric System. I find that this results in a great saving of time, although I
was familiar with the English system for thirty years of my life, and have only
learned the Metric System comparatively recently. In the Transvaal the Rail-
ways and the Mines already use the Metric System. If the System were made
universally compulsory in both Colonies it would be a gain indeed to the whole
community, from the children at school to the scientific men engaged in the
most intricate calculations.

I shall now describe the different sections of the three Colonies in
detail.

The Koebberg District lies between 300 and 600 feet above sea-level,
and is typical of the South-Western corner of the Cape Colony. The average
rainfall is about 30 inches per annum. This is one of the wheat districts of
the Colony. The abundant winter rains render it independent of irrigation
in winter. The average size of the farms may be taken as 2,000 acres, of which
about half the area seem to be under cereals of some sort, principally wheat
and oats. These areas appear to be too large for their profitable working by
comparatively poor farmers and the ploughing was done perfunctorily. There
is a universal complaint against want of rainfall in winter. At no rotation of legumi-

uous crops with cereals is over-emphasized, but cereals are made to follow
cereals with occasional fallows, this is not to be wondered at. One of the
successful farmers recently sown Lucerne with his wheat in certain of his
fields and has been rewarded fivefold. It is contended that there is no market for
beans and other leguminous seeds in Cape Town, and that consequently they cannot be
profitably grown, and that Lucerne cannot survive the summer drought. If an
disposable gateway was constructed through this district it would be easy to
disperse fodder, and very possibly the Egyptian clover (berseem, legumia)
would be an excellent rotation crop for a climate like that of the Koebberg, and it
was a winter annual. Egypt and the Cape Colony might mutually aid each
other by making an exchange of seeds. Egypt is particularly rich in leguminous,
while the Colony is rich in fodder crops capable of existing under conditions
of extreme drought. A crop like the Egyptian clover grows in rotation with
wheat might store the soil with nitrogen and probably destroy rust in the
wheat.

In these districts reservoirs for providing perennial irrigation would be
premature at present. While the landowners had thoroughly developed their
single crops per annum it would be thought of double crops. All over
the Colony leguminous might be grown with cereals with great benefit to
make oil cakes, and utilise the cake for cattle feeding. Both in India and
Egypt the legumes consume immense quantities of lentils (“ads” in
Egypt, and “dall” in India) with great advantage to themselves; while beans
form one of the principal foods of donkeys and poultry in Egypt. In India
horses, sheep and cattle are fed almost exclusively on “gram,” which is
another lentil. A change from measures to “gram” would be a great gain to
The presence of perennial irrigation allows of vegetables being produced throughout the year and of double cropping on rich well-manured lands. It would also allow of linseed in the valleys, which would be of great value for feeding stock. Reservoirs would, however, pay nowhere except near the important centres.

What Basutoland wants is better cultivation with the introduction of leguminous crops and root, in rotation with cereals. Suitable manures and crops would do much more for the country than irrigation, and would do it at one-fifth the cost. The way to proceed would be, I think, to have small model farms at all the Residencies, where practical experiments might be carried on to prove which were the most suitable leguminos and roots for the country, and which were the best manures. If obviously satisfactory results were obtained, a people so intelligent as the Basutos would certainly initiate them. An effort should also be made to encourage a taste for pulses among the people. It may seem a homely thing to educate people to eat one class of food rather than another, but the future agricultural development of the country depends on it. As the Chief Commissioners of Basutoland and all the Commissioners are ardent agriculturists and take great interest in forestry, the experimental farms attached to the Residencies will begin life under happy auspices. The comparative value of perennially irrigated land, the land depending entirely on rainfall, might be also studied to great advantage.

The dangerous weed peculiar to the country is the yellow tulip which is increasing alarmingly in certain districts. I think that these noxious weeds, peculiar to certain districts, are encouraged in their growth by the lying fallow of large tracts of land every year. During the fallows, the veld grasses are absent, and the weeds have it all their own way. These weeds not only increase much in the fields but their seeds are carried into the neighbouring grass tracts, and so spread so some agriculturists that the increase of these weeds is due to the burning of the grass in the wrong season. If the grass is burned in September and October the noxious weeds increase with difficulty, but if the burning is delayed to January and February the weeds make headway.

The conquered territory consists of that part of the Harrismith, Ficksburg, Ladybrand, and Wepener Districts which borders the Caledon River, and which, generally speaking, drains into the Caledon River. The country lies between 4,500 and 5,600 feet above sea-level, and has a rainfall varying from 25 inches near Wepener to 30 inches at Ficksburg and Harrismith. In this territory, as in Basutoland, the rainfall is generally sufficient in August, September, and October to allow of wheat being sown between June and August and reaped in December without irrigation. The agricultural value of the land improved, as one approaches the Drakensberg, as the rains are more constant. The soil is covered with good grass, and agriculture is steadily on the increase. This tract is universally considered the best suited of any in South Africa for European settlers. The springs are numerous. In the Karoo no springs are met with in the hills, while those in the valleys have a general discharge of four cubic feet per minute. Here the springs in the hills run to four cubic feet per minute, and those in the valleys to 40 cubic feet per minute. The streams are collected in reservoirs and are capable of working small corn mills.

Wheat and Indian corn are the principal crops, and there are large flour mills on the Caledon and its tributaries, which can be worked for nine months per annum. Mr. Newman has constructed a large reservoir by means of a masonry and earthen dam on the Lower River between Ladybrand and Thaba Nchu, and works a very important corn mill with the water power developed. Just below the mills there are large areas of land eminently suited for perennial irrigation on which the water escaping from the mills might, with great advantage, be utilised, but the proprietors have never used it. I was told that the proprietors were preparing to make canals and utilise the water when the war broke out.

The Caledon River, which drains the whole of this tract and a large area in Basutoland, has a bed width of some 200 feet and a depth of 30 feet in flood near Wepener. The flood discharge may rise to 30,000 cubic feet per second, while the low supply falls to some 10 to 20 feet per second. The river has a gentle slope for South Africa streams; and runs in an eastward channel down the middle of a grass-clay valley. There are scarcely any important dykes of rock traversing the stream between Ficksburg and Wepener, with the exception of the well-known NOTES. There are, however, minor dykes and bars which would be very useful for weirs.

The land on both sides of the Caledon River is first-class agricultural land, which might be very considerably improved in value by the construction of impounding weirs across the river at a mean distance of some seven miles from each other, and by the taking off of high level canals from above regulating weirs. The impounding weirs should be constructed of stone pitching with the largest possible blocks on the downstream side, consolidated in the middle, with small boulders, pebbles, and fine pitching on the upstream side. The whole should be enclosed in strong wire netting, with a central core of asphaltic masonry some four feet wide. Each weir should be provided with three under-sluices of cast iron. Each sluice would be ten feet high and six feet wide. The openings would be regulated with screw gates. Where good dykes were met with and the bluffs sufficiently high, masonry weirs 30 feet in height would replace the weirs of stone pitching. The judicious working of the under-sluices in the floods during their muddy stage would insure the channel of the river against silting up; and it would thus happen that the weirs would convert the rivers in times of low supply into a series of reservoirs of consider- able capacity. Each weir might be counted to store 60,000,000 cubic feet on the average of some 600 acres. Each weir would cost, on the average, about £2,500. Forty such weirs would cost £100,000, and insure the perennial irrigation of 24,000 acres. The stone dykes would naturally be utilised for masonry weirs and canal heads. In their absence, any suitable rocky headland or bluff (of which there are many) might be utilised as the site of a regulating weir. The canals would take out with their heads about twenty feet above the river bed, and would be made capable of irrigating some 100,000 acres with the aid of the floods brought down from the Drakensberg. Of this area one-fourth 30,000 acres under lucerne; and 12,000 acres, or the whole 24,000 acres if necessary, under beetroot, for which soil, climate and seasons are most favour-
The tern half of the Orange River Colony lies to the East of a line drawn from Klerksdorp to Aliwal North. The height varies from 4,500 to 5,000 feet above the sea-level, and the mean annual rainfall from 22 inches in the extreme West to 28 inches in the extreme East. The country may be described as undulating plains of grass with a few hills interspersed in places. In South Africa every hill is a mountain, but these are generally hills. The lands are drained by the Klip Wilge, Rhenoster and Vaal rivers. The whole of this country is excellent pasture land, and covered with veld grass. The rainfall is deficient in August, September, and October, but plentiful in December, January, February and March. Indian corn can be grown without any irrigation at all. Wheat may also be grown in the extreme East in ordinary years. The rivers may be described as deep trenches running from East to West, with a mean slope of about five feet per mile, and a mean depth of some fifty feet below the general level of the valley traversed by them. In the level reaches the slope may be taken as about 2½ feet per mile, and the remainder of the fall is at the rapids or the stone dykes, which are very numerous on all the streams. As the streams are all torrents in floods, which have no长久 duration, the dykes are in great part sandstone. The short duration of the floods has enabled the sandstone dykes to hold their own. On the Orange, Vaal and Caledon rivers the sandstone has everywhere been eaten away, and only the hardest dolerite or granite has been able to resist the action of the water and remain as dykes. The floods on these rivers are severe, and attain a maximum of four cubic feet per second per square mile in extensive catchment basins. The minimum discharge is practically zero.

In this country perennial irrigation could ensure as good crops as in the conquered territory, but at a greater expenditure of water. Except in the extreme East, where the conditions are similar to those on the Caledon, I should say that 150,000 cubic feet of stored water should suffice for the perennial irrigation of an acre of land. Each square mile of country might be counted on for 4,000,000 cubic feet of water in a year of drought, or for 25 acres of perennial irrigation. In ordinary years three and four times this area might be depended on, and canals should be made, capable of carrying this extra water.

The value of perennially irrigated land to land depending on rainfall may be taken as £1 to one shilling in this district, and also in the high veld of the Transvaal, the conquered territory, and in Basutoland. In the south-western half of the Orange River Colony is may be taken as £1 to sixpence. In the eastern Karoo as £1 to threepence, and in the western Karoo as £1 to one penny.

In the north-eastern half of the Orange River Colony the good veld may be taken as £1 per acre, and the perennially irrigated land as £20 per acre. Of course it is understood that no reasoning man would think of perennially irrigating any but the best land in the country.

Here, as everywhere else in South Africa, water must be stored for irrigation. In all the rivers and creeks in this section I should store water in the manner proposed for the Caledon River Valley. Storage will be far simpler than on the Caledon River as the numerous stone dykes will provide excellent foundations. As the valley rivers are considerably steeper than the valley of the Caledon River it will be necessary to construct the weirs 25 feet high instead of 20. This, however, will entail no difficulty as the foundations will be everywhere on rock. The conversion of all the rivers into perennial streams by this method will provide ample water for the agricultural requirements of this tract for many generations, especially when it is remembered that Indian corn can be grown without any irrigation at all.

We have at Kroonstad on the Vaal River an excellent example of what may be expected from the construction of even small weirs on these rivers. The Kroonstad Ford is located on a very solid sandstone dyke which crosses the river. There must be a drop of some 30 feet at the dyke itself. On the crest of the dyke is built a masonry wall some five feet high and six feet wide, which holds up the water and provides a reservoir in the river bed of no mean proportions. The water supply of Kroonstad is pumped up from this reservoir, which makes no attempt to stop up through the Vaal River carries much silt in flood. As illustrated in the description of Mr. Southey's farm in the Eastern Provinces of Cape Colony, there is no tendency for silt to deposit up-stream of weirs when the velocity is considerable. The Paracha weir on the Retva River is a good example of such work on a swift stream. The weir is thirty feet high and does not cause the river to silt up.

This section of the Orange River Colony lies to the West of a line drawn from Klerksdorp to Aliwal North. The height varies from 4,000 to 4,500 feet above sea-level, and the mean annual rainfall from 22 inches in the extreme east to 15 inches in the extreme west. It must always be remembered in connection with these varying figures for rainfall, that the better the rainfall the less the comparative difference between maximum and minimum rainfall, while the less the rainfall the greater is this comparative difference. It is for this reason that years of drought are very severe when the rainfall is scanty.
The mean rainfall of Kimberley may be taken as 18 inches, but the minimum is 12 inches and the maximum 30 inches.

The country may be described as very slightly undulating plains covered with grass and dotted with hills in the northern two-thirds and broken-up hilly ground in the southern third.

The pan formation is quite a feature of the northern part of this country. The lower reaches of the Zand and Yet Rivers, and the Molopo and Eet River to join the Vaal, traverse these undulating plains. I have reached me at Bloemfontein, that the Americans were waking up to the importance of these pans as reservoirs in the arid regions of Western America. Unfortunately no levels of any kind exist in this part of the Orange River Colony, but guided by my Mendez I was confident that the country possessed in these pans a reserve of wealth of no mean order. A pan two square miles in extent and filled with 25 feet of water would contain 700,000,000 cubic feet. The upper seven feet or 300,000,000 cubic feet would be lost by evaporation, leaving 400,000,000 cubic feet. If only half of this were used for irrigation every year we should have a perennially irrigated area of 2,500 acres on a single pan; and the pans are very numerous. All the rivers in the pan region should be turned into the pans in the flood season and be made to conserve their waters for use in the irrigation season. On their way to the pan, it should certainly be possible in this flat country, to turn the flood waters over extensive areas and so cover the ground with a rich deposit which would be capable of very profitable cultivation. To ensure this cost and I should not hesitate to build solid overflow weirs of even 50 and 60 feet in height. The whole of lime and stone everywhere, and masonry such as is needed for low dams, should be cheap indeed, as Mr. Southey has already discovered. With skilful treatment, this, the poorest part of the Orange River Colony, should be converted into really valuable ground. The most thoroughly British city in the whole of South Africa is Kimberley, and it is depressing to an Englishman, as it walks its streets, to think that the day when the diamond mines are worked out this city will disappear as completely as a miners' camp. With the aid of pan irrigation, however, it should be possible to convert 100,000 acres of veld into first-class agricultural land and so conserve Kimberley for all time. If Mr. Rhodes were to devote part of his wealth in the direction I have indicated, he would do more for Kimberley than even what he did when he threw himself into the town on the eve of its being beset. He would not only give permanent life and prosperity to a town, with which his name will be forever connected, but he would make a profitable investment of his wealth which might benefit any charity he might wish to aid.

No South African statesman should rest satisfied with the transitory character of the wealth of his country. Irrigation, and irrigation alone, can secure permanent wealth to any part of the South African continent.

From inquiries, observation, and comparison with other countries, I should say that in those parts of South Africa which lie below 1,000 feet above sea level, and are situated in the arid or semi-arid region, a rent of £2 per acre per annum could be easily paid for perennial irrigation anywhere near a railway. In the semi-arid regions between 1,000 and 2,500 feet above sea level of £1 10s. could be paid. Where the ground is over 2,500 feet in height, a rent of £2 per acre per annum could be paid. Near cities and important centres a higher rent could be paid. Allowing for perennial irrigation in nine years out...
The Orange and Vaal Rivers.

The Orange and Vaal Rivers meet near Douglas to the South-West of Kimberley. The catchment basin of the Orange River is about 35,000 square miles, and of the Vaal River 65,000 square miles. The maximum flood discharge of the Orange must be over 200,000 cubic feet per second, and of the Vaal 80,000 cubic feet per second. The ordinary flood of the Orange River may be taken as 50,000 cubic feet per second, and of the Vaal 10,000 cubic feet per second. It will be evident that the rainfall in the basin of the Orange is considerably in excess of that in the basin of the Vaal, and that the hills are steeper. The Vaal is in flood from January to April, while the Orange is in flood from December to April. Storms produce temporary floods in the other parts of the year. The rivers are at the lowest in August, September and October, when the discharge may fall to 30 cubic feet per second in a year of deficient rainfall. The Vaal has a bed width of some 400 feet and a depth of water in flood of 25 feet, the Orange has a bed width of 800 feet and depth of water of 35 feet. The general slope of the Orange River may be taken as three feet per mile up-stream of Aliwal North, and four feet per mile down-stream of Aliwal. The slope of the Vaal may be taken as four feet per mile up-stream of Klerksdorp and three feet per mile down-stream of Klerksdorp. Except in the neighbourhood of Barkly West the Vaal has more numerous and capable up-stream of Klerksdorp than what it has down-stream of Klerksdorp. The Orange River, on the contrary, has numerous rapid down-stream of Aliwal North and scarcely any up-stream.

The country traversed by the Orange River is rugged and mountainous, while that traversed by the Vaal is undulating and fertile. From its source to where it leaves the Orange River Colony the Vaal may be used everywhere for irrigation, while the Orange River can be utilised nowhere in the Orange River Colony, and not even in the Cape Colony until one has passed Colesberg and is halfway to Hopetown. I leave out of count the scattered patches of foreshores in the troughs of the rivers which any riparian owner can irrigate with works of very ordinary magnitude.

In contemplating irrigation works on these two rivers it is not necessary to complicate matters by having to provide for navigation. With the steep slopes and torrential floods which we have on these rivers navigation is out of the question.

From some point midway between Colesberg and Hopetown it would be possible to take out a canal on the left bank of the Orange River, which should be capable of irrigating an extensive tract of country. The canal would tail into the Orange River near Prieska. The fall would be 400 feet and the distance 300 miles. An overflow weir of some 60 feet in height of the type of Beira weir would be constructed along one of the solid dykes which traverse the river. This weir would be only a diversion weir, and the bed of the canal would be ten feet below its crest. The canal itself would follow the windings of a contour on a slope of two feet per mile, and kill every pan and depression it encountered. All the storage would be made in pans and valleys. In this way it would be possible to take water freely from the Orange River in flood, and by means of these pans to insure perennial irrigation to extra-ordinarily large areas of land. A storage of 250,000 cubic feet of water would be needed for each acre of land to be perennially irrigated. With the aid of its flood waters the canal would be capable of irrigating double the area. The solid works would be cheap since they could be built in lime mortar, while the canals would be dear, as rock might be frequently encountered. It would therefore be true economy to construct numerous weirs and small canals.

One weir and one grand canal would not be economical here as would be the case in India. Wherever rock was encountered it would be necessary to drop the bed of the canal some four or five feet, decrease the width and increase the slope. In this way, by taking advantage of every feature of the ground, many thousands of pounds would be saved.

A second 60 feet high weir might be constructed near Prieska, and a canal dug to the South of Kenhardt. The distance from Prieska to Kenhardt is 230 miles, and the fall, according to Mr. Gamble, is 650 feet. This canal might be led into the extensive pans South of Kenhardt and be employed in vail irrigation on a scale not dreamt of yet in South Africa. At this weir, flood embankments would be needed to keep the river within its banks. Advantage might be taken of this weir to provide flood or "vail" irrigation for the extensive flats near Prieska on both banks of the river and to add some 10,000 acres to the wheat area of the Colony.

A third 60 feet high weir might be constructed at Upington, and a canal dug into Bushman's Land South of Pella. The fall from Upington to Pella, according to Mr. Gamble, is 500 feet and the distance 200 miles. This canal would command an immense area of what, I am given to understand, is excellent land but quite waterless. Care would have to be taken in traversing the apparently low depression down which the Hartebeest River runs. According to Mr. Gamble's levels, Kenhardt is 100 feet lower than Upington.

In the districts traversed by the last two canals, wheat is a winter crop as it is in Egypt, and it would be possible to irrigate directly without the aid of reservoirs. True, there would be only one crop per annum, but it would be an extraordinary rich crop, sown on the rich alluvium of the Karoo, and matured with the muddy waters of the Orange flood.

All the poor whites in South Africa might be settled on these canals for many generations. In all questions connected with the Vaal and Orange Rivers, I am indebted to the extreme courtesy of Mr. Litchfield, who has spared no pains to place every kind of information at my disposal. For the knowledge of the country South of the Orange River, I am also indebted to Mr. Bain.
The Cape Colony Government might certainly employ a couple of strong brigades of engineers in thoroughly sifting the question of the utilisation of the Orange River. From Kaffraria, it is the most reliable river in South Africa; it carries rich fertilising water, and traverses healthy, cultivable lands in its lower reaches, where we have left behind the high altitudes in which frost in winter is so much dreaded. Both banks of the river should be thoroughly examined; and in considering the projects the Government may rest assured of this fact, that every extra pound spent on the dams will result in the saving of ten pounds on the canals. Get the river water out of its trough and all will be well. Leave the water in its trough and nothing can be done with it.

A hundred thousand acres of irrigated land on each of these canals would require a discharge of 600 cubic feet per second per canal, assuming that one cubic foot per second would suffice for 150 acres. With labour saving machinery and weirs of the type of the Eetwa River Weir, this irrigation should be provided at a cost of £5 per acre. A water rate of ten shillings per acre per annum would cover all expenses and pay five per cent. on the capital.

If a careful survey were made of the trough of the Orange river, which, I understand, has an average width of 11 miles from Frieska Westwards, while half a mile is ample sufficient for the full flood waterway of the river, it might be found that a series of stone spurs and obstructions would suffice for the reclamation of an average width of one mile of land along hundreds of miles of the river. Here there might be a possibility of creating at a very moderate expenditure some hundreds of thousands of acres of first-class land which would be capable of easy irrigation, and have a value of £25 per acre and upwards.

I have not met anybody who knows anything of the country to the North of the Orange River.

Now come to the Vaal River irrigation. Here we have conditions differing entirely from those on the Orange River. The country traversed by the Vaal has generally a high altitude, and direct flood irrigation would not be of much value. For any scheme for storage or irrigation up stream of the junction of the Witte River and the Vaal River near Grobelan's Ford, it will be necessary to treat the Vaal like the Witte or the Vaal in the North-Eastern half of the Orange River Colony. The river and its tributaries are provided with many dykes, on which overflow storage dams of 30 and 10 feet in height might be built of masonry. Such dams would be provided with two good scouring sluices each, of the dimension proposed for the Caledon River. Below the junction of the Witte River with the Vaal, and up to Klerksdorp, where the pan formation may be said to begin, it would be found to be most economical, on the solid foundations which we have here, to build unsubmersible storage dams some 100 feet high of ferro-concrete, and provide them with sufficient sluicing to pass the whole of the flood waters of the Vaal. Suitable sites would be found, I think, at Engelbrecht's Ford up-stream of Vereeniging, at Parys, and at Kromdrai down-stream of Klerksdorp. I am not sure whether a height of a hundred feet could be obtained, but if it could it should certainly be adopted. If the hills in the vicinity of the river would not allow of a greater height than this, then the dam should be adopted with some little underlining. The canal should lead off with its bed some twenty feet above the bed of the river. This would suffice generally on the Vaal as far as Klerksdorp.

The valley of the Vaal leads itself perfectly for irrigation. The river falls at a rate of some three feet per mile, and as would start with its water surface delivering 200,000 cubic feet of flood irrigation, it would receive gradually from the river, and on a length of thirty or forty miles command as much land between itself and the river as it could irrigate. The soil in the vicinity of the Vaal River, is as a rule, well-suited for irrigation. Such irrigation could be provided at an expenditure, I estimate, of £10 per acre, and a water rate of £1 per acre would pay all expenses and five per cent. on capital.

For the reach of the river between Klerksdorp and Kimberley, it should propose diversion weirs or overflow dams on the dykes which traverse the river, of any height from 20 to 50 feet, for the sake of leading the Vaal River water out of its valley and getting it to command the lands to be irrigated. Here we have entered the pan formation, and Nature itself has provided the reservoirs for storing the water. There is much excellent land on the Southern bank of the Vaal between Hoopstad and Kimberley, which would be commanded by such a canal. Under the heading of the South-Western half of the Orange River Colony I have already given a very full description of "pan" irrigation. The Northern bank of the Vaal River is as well suited for irrigation as the Southern bank. The water of the Vaal River could be turned into the Hart River at a high level and utilised for irrigation in the Cape Colony.

As the Orange and Vaal Rivers are both boundary streams between the Cape Colony, the Orange River Colony, and the Transvaal, it might save considerable trouble and ill-feeling in the future if the three Colonies were to settle their claims in the respective rivers by the Cape Colony accepting the waters of the Orange River as its property, while the Transvaal and Orange River Colony divided the Vaal between themselves.

It will be noted that I have not spoken anywhere of irrigation by pumping. As irrigation in South Africa depends in nearly every case on reservoirs, it is as easy and more economical to provide flood irrigation. Where coal is cheap it might be profitable for individuals in well-favoured situations to employ pumps, but it certainly would not pay on any scale to first stone water and then pump it. In Egypt, when the land is worth £20 per acre and coal costs £1.10s. per ton, it costs £2.10s. per acre to irrigate with a lift under 30 feet in height. So pumping is done at greater lifts, as it is not considered profitable. Lifting water by windmills for irrigation may pay in town gardens, it will scarcely pay anywhere else.

Locusts are one of the plagues of South Africa. If all the States would combine and devote annually some £20,000 each to the extermination of locusts, it would be possible to gradually exterminate this pest. Though the area of the country is large, still it is always being traversed by large bands of men, shepherds and Colonials, and the land itself is so extraordinarily bare, that it should not be found very difficult for these bands to destroy the locusts. Between Bloemfontein and Kimberley, while moving with Major Brededorp, of the South African Constabulary, I saw great numbers of the foot-
The Bush Veld and the Low Veld.

The bush veld lies to the North of the dolomite region, and the low veld lies to the North and East of the bush veld and the high veld. They cover some 50,000 acres. These low-lying areas are traversed by comparatively high ranges of hills, as the Zoutpansberg, the Drakensberg, the Lobombo, and others, but the low lands cover by far the greater part of the area. The bush and low veld may be considered as the lands lying generally below 4,000 feet above sea-level and North of the 26th degree of latitude. These lands are, as a rule, capable of producing tropical crops wherever irrigation can be secured. They are generally covered with scrub and grass and are feeding grounds of the flocks and herds of the Boers during the winter months. This practice of trekking from the high veld to the low veld in winter is due to the fact that the winter frosts kill the grass in the high veld, and as the Boers have not, as a rule, sown any root crops or pumpkins or other crops on their lands in the high veld, they are compelled to travel down to the regions where frosts are unknown. However, informed by advanced Boer farmers that the trekking results in 10,000 acres of veld having to do the work of 5,000. If suitable crops for feeding stock were sown with the aid of the rainfall on the high veld, and the cattle and sheep folds built between belts of blue gums or pine trees, it would be of advantage to the farmers, and double the value of their holdings in the high veld. The winter in South Africa is not as severe as the European winter. The only thing needed on the high veld is the planting of a few belts of trees, which grow with great rapidity, and the cultivation of roots and feeding stuff for the flocks and herds.

The low veld itself is generally well supplied with water and capable of being extensively irrigated, and as it can produce many of the valuable tropical plants, it should be a possession of great value. It has, so far, lain undeveloped, owing to the climate being unattractive for Europeans. Europeans can't live and work in the climate, while British Indians, who could live and develop the country have not hitherto been allowed to enter. The Kafir is not a worker and developer of anything. He will never learn from the European, for the European in South Africa does not work with his hands, but he will learn from the Indian. If a hard and fast line were drawn between those regions where the European can work and live, and where the Indian could reside, and the latter are thrown open to Indians and Kafirs, who would have the power of becoming owners of the land with full proprietary rights, we should soon convert the low veld into a country capable of paying substantial taxes. It would be necessary for the Government to impose a very light tax on the whole area, say one penny per acre per annum for the first two years, two pence per acre per annum for the second, third, and fourth years; three pence per acre per annum for the fifth, sixth, seventh, eighth, and ninth years; and finally one penny per acre per annum for the next ten years, with a final maximum which would be fixed by a commission appointed for the purpose. This healthy innovation would have as its first result the thorough back into the lands of the Government of large tracts of country which to-day are a useless possession to the people who own them. Such people have no intention of developing these lands and are practically nothing but paper landowners. In a few years the proprietors of the lands would have handed back to the Government all the lands they did not care to or could not work, and would have retained and begun developing all the lands they could develop. With these lands in possession, the Government would invite British Indians and Kafirs, and make a beginning of setting the country. In this way do I think it would be possible to make these extensive tracts in the Transvaal, not only self-supporting, but a source of appreciable revenue to the country. When the tide of Indian immigration had set in projects for irrigation and further improvement of the land might be undertaken. The low veld could produce rice and tropical plants, and would be in no way compete with the temperate and sub-tropical crops of the European farmers on the high veld and dolomite regions.

Indeed, if Indians and Kafirs were confined to the tropical belts, and the European to the temperate belts, we should not see the absurd spectacle, which we see to-day, of the best parts of the temperate zones being inhabited almost exclusively by Kafirs, while the Europeans with great jealousy were keeping the Indians and Kafirs out of the tropical belts.

This tract lies to the South-West of a line joining Lichtenburg and Klerksdorp, and may be called the Bloemfontein District. It covers some 10,000 square miles, and may be said to be some 4,000 feet above sea-level. It is traversed by a few hills, but is generally level, and consists of a sandy loam. The veld is covered with grass. The Hart River flows through the middle of it, and the Vaal River forms the Southern boundary. The rainfall may be taken as 18 inches per annum. According to Mr. St. Vincent Eakin, who knows the district intimately, all crops except Indian corn need irrigation, and Indian corn cannot be counted on when the rainfall is late, as the early frosts destroy it.

I regret that I had no opportunity of visiting this country owing to its disturbed state, but from its position it parables the character of the Northern two-thirds of the South-Western half of the Orange River Colony, to which reference should be made.

With the exception of the single reference to land taxation under the heading of the "Bush Veld," I have said nothing on the subject of Land and Water Rates, and yet no wholesale improvements are possible in arid and semi-arid countries without land and water taxes of some kind. Without taxation an individual may possess a million acres of land and do nothing to improve it with perfect impunity. Others are prevented from improving it, the State cannot interfere and whole regions lie waste and barren. All Eastern Governments have resolved this as they have generally to do with regions where Nature does so little and human beings have to do so much. Europe with its wonderful climate differs generally from this rule. In South Africa, however, the Government must follow the precedent of the arid and semi-arid regions of the world if it wishes to insure success.

There is scarcely any part of South Africa where agriculturists cannot afford to pay £1 per acre per annum for perennially irrigated land. It may be considered that a spring is capable of irrigating 150 acres per cubic foot per
second, or 3½ acres per cubic foot per minute. It would be perfectly fair for the State to put on every perennial supply of water a tax of £10s. per cubic foot per minute, whether the irrigation were flow or lift. If the water was supplied by a natural spring or by an artificial reservoir created by the Government it would be taxed equally. Artificial reservoirs constructed by private parties would not be taxed. The perennially irrigated lands might be taxed instead of the water supplied, but the taxing of the water supplied would encourage economical usage and has much to recommend it. Judging from the springs I have seen and the area on which they operate, I should say that the natural springs of the Transvaal would bring in a yearly revenue of from £50,000 to £200,000 per annum, which could be easily paid. The springs in the Orange River Colony would not bring in a tenth of this revenue. Artificial irrigation provided by reservoirs and canals from borrowed capital would bring a handsome direct revenue in these countries as it does in India. The indirect revenue would be a material gain to the Government of no inconsiderable amount. A uniform rate of £1 per acre per annum for perennial irrigation would enable extensive projects to be undertaken everywhere.

We have so far considered water rates. We now come to the question of the land tax quite independent of the water tax. The land in the Orange River Colony may be considered as having a mean value of 10s. per acre. Such land could pay an annual land tax of 6d. per acre per annum. It would be resisted at first, but it would result in an abatement of useless landlords, and a substitution in their place of men who were determined to work their lands to the best advantage. The growing importance of the poor white races is now, in the end, forcing the hand of the Government if nothing is done now. On a basis of 6d. per acre per annum the Orange River Colony could pay £200,000 per annum. The taxation might be introduced gradually, but if the country is ever to be developed there must be some systematic taxation which will not allow worthless landlords to accumulate land. In the dolomite region, the high veld, and the South-Eastern Corner of the Transvaal land may be taken as worth 10s. per acre. Such land should pay 4d. per acre, and would bring in a yearly tax of some £30,000 per annum. Here, again, irrigation works would add to the revenue as in the Orange River Colony.

For the bush veld, capable of great development and yet quite undeveloped, special taxation would have to be devised as already proposed under the heading of "The bush veld."

The United States of America are considered the least paternal Government in the whole world, and yet winter after winter I have seen Egypt visited by capable and keen Americans representing the Agricultural Bureau at Washington, who collect information of every kind about agriculture and send home good specimens of every kind of agricultural produce. These seeds are sown on the experimental farms of the different States, and if any variety proves itself well-situated to any particular region, the farmers are immediately informed and provided with seed corn. Not only are agents sent to Egypt but to every interesting agricultural country in the world, and in this way the States keep at the head of the world in agricultural production. Such a bureau might be established for South Africa with great benefit to the agricultural community. The South African agents would bring back with them leguminous seeds, vegetable products from other arid and semi-arid countries, and above all labour-saving machines from America. In this way life might be imparted to agriculture in this country, while labour-saving machines would halve the expenditure on water-courses and earthwork of all classes.

The same bureau would in South Africa itself attend to rain gauges, discharges of streams, value and extent of crops, and every kind of information necessary for forming a just appreciation of the agricultural values of different parts of the country.

Knowing well the interest Your Lordship takes in the agricultural development of South Africa, I have been emboldened to write at great length and very freely of irrigation possibilities of the three Colonies which I have travelled through. A perusal of the report will, I feel confident, have convinced Your Lordship that, with the exception of the South-West Corner of the Cape Colony, the "Conquered Territory" of the Orange River Colony, and the high veld of the Transvaal, the agricultural development of the whole country depends entirely on irrigation. The most fertile plateaux of South Africa has a rainfall suited to tropical countries, and a climate which belongs to a temperate zone. The autumn rains of February and March, which are monsoon rains, would, in a country like India, be of infinite value; but followed, as they are in South Africa, by a severe and biting winter, they are of little value indeed for agricultural purposes. The long winter and spring droughts, and the uncertain summer rains absolutely prohibit agriculture of any advanced kind.

In about four-fifths of the Cape Colony, and in one-fifth of the Orange River Colony, no crops can be grown without irrigation if there is to be any certainty of reaping a harvest. In one-fifth of the Cape Colony, half the Orange River Colony, and two-thirds of the Transvaal, the main crop is corn, potatoes, roots generally, and pumpkins, for feeding stock in winter, can be grown with the aid of the rainfall and matured in all but years of heavy drought. In these years more tracts of land become suitable for agriculture, and with increased rainfall and the use of irrigation, the output of corn is increased. The same report is true of the Cape Colony, and the same report is true of the Transvaal, the agricultural development of the whole country.

The extraordinary fertility of all those localities where nature has provided springs of perennial water, and where the farmers have been able to utilise it, in spite of the laws which are as hampering as they are ridiculous, points the way to the true road where lies the permanent regeneration of South Africa. We have only to imitate nature and impose on the surface of the ground the same water which she stores in caverns and basins, and we shall have the permanent prosperity of the country on a sound basis. The Kimberley basin, within a few miles of Kimberley, irrigated by the rive of the diamond mines is a sure guarantee of what even inferior water can do with the rich soil and climate of South Africa.

In connection with this question, it is fortunate that nearly everywhere in the Transvaal in the greater part of the Orange River Colony, and over
wide areas of the Cape Colony, the rainfall is sufficient in quantity in even the very worst years to allow of the storage of water on a very large scale. On a rough calculation I should say that with the aid of its rainfall and the Orange River, the Cape Colony should be able to ensure the perennial irrigation of 1,000,000 acres, the Orange River Colony of 750,000 acres, and the Transvaal of 500,000 acres in the high-lying regions where Europeans can live and work, and 1,000,000 acres in the low tracts which should, I think, be thrown open to our fellow British-Indian subjects. On this latter point I have written fully elsewhere and shall say nothing further here.

South Africa with an additional 3,000,000 acres of perennially irrigated land gained at an expenditure of £30,000,000, and valued at £100,000,000; and also with 10,000,000 acres of land under crops depending on rainfall, which might be valued at another £100,000,000, would be a very different country from that which it is to-day. An addition of £200,000,000 to the permanent wealth of South Africa would enable the country to contemplate with serenity the dark days of its gold and diamond industries. Without such agricultural wealth to lean upon, the exhaustion of its mines will plunge the whole country into conditions of poverty which no statesman can contemplate without dismay, certainly no statesman of Your Lordship's ability and proved devotion to the welfare of the South African continent.

I have the honour to be
Your Lordship's obedient servant,

(Signed) W. WILLCOCKS,

Managing Director Daira Sainia Company, Egypt.