The improvement of native agriculture in relation to population and public health / by Sir A. Daniel Hall.

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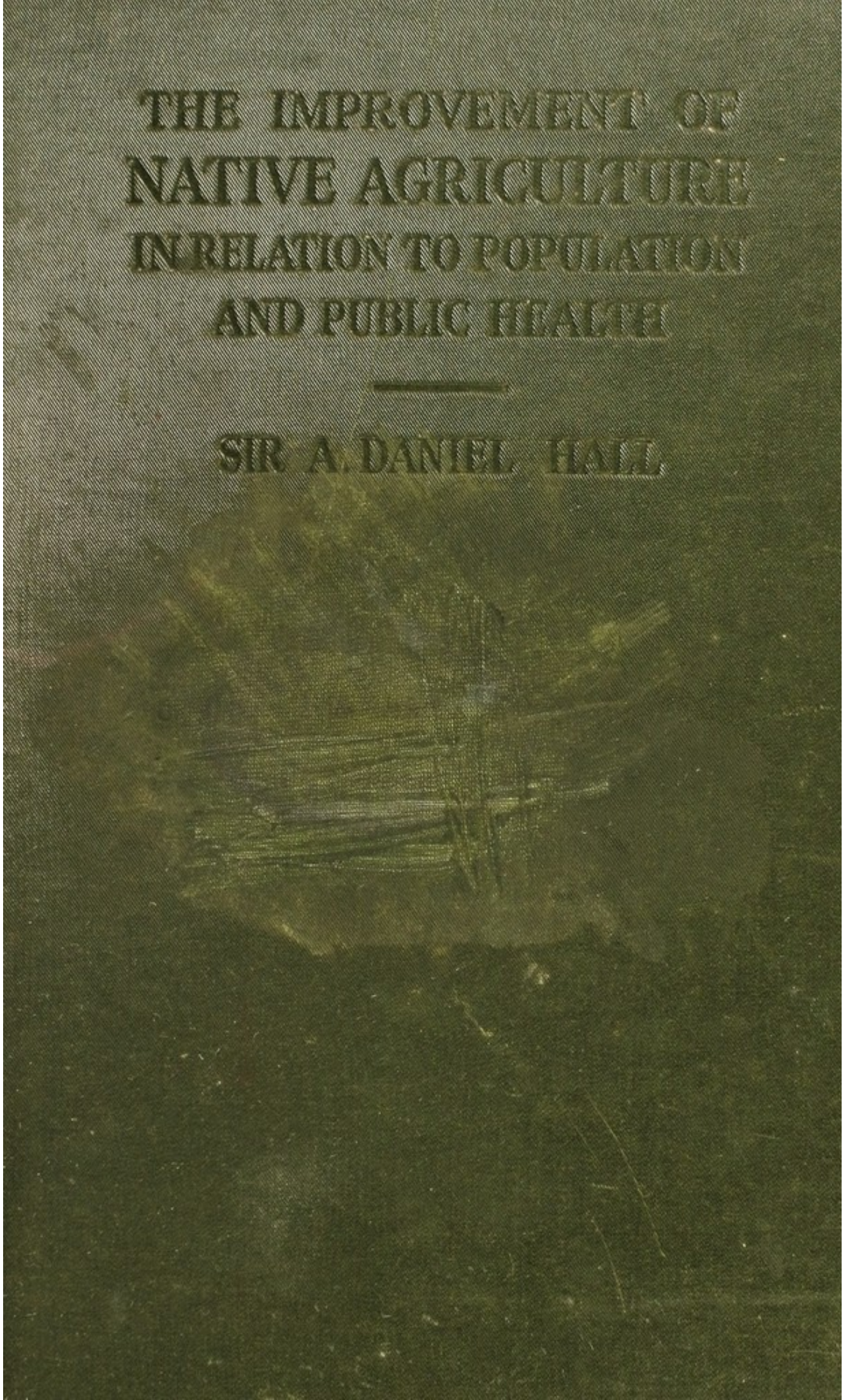
SIR A. DANIEL HALL



THE IMPROVEMENT OF NATIVE AGRICULTURE IN RELATION TO POPULATION AND PUBLIC HEALTH

UNIVERSITY OF LONDON
HEATH CLARK LECTURES, 1935
delivered at
The London School of Hygiene and Tropical Medicine

The Improvement of Native Agriculture in relation to Population and Public Health

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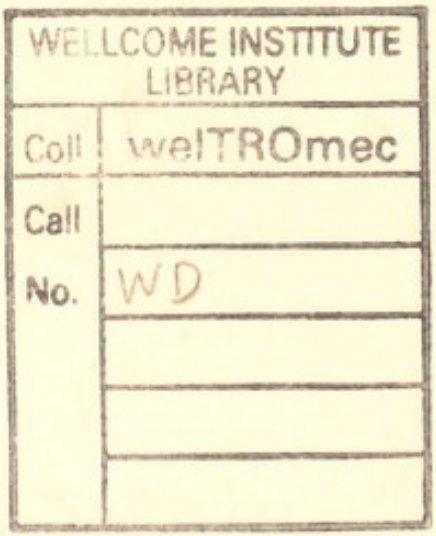
OXFORD UNIVERSITY PRESS
LONDON : HUMPHREY MILFORD
1936

OXFORD
UNIVERSITY PRESS
AMEN HOUSE, E.C. 4
London Edinburgh Glasgow New York
Toronto Melbourne Capetown Bombay
Calcutta Madras
HUMPHREY MILFORD
PUBLISHER TO THE
UNIVERSITY



PRINTED IN GREAT BRITAIN

PREFACE

WHEN the University of London did me the honour of inviting me to deliver the Heath Clark lectures and I began to consider in what way the conditions laid down in the Trust Deed could be met, it seemed that I might be able to serve a useful purpose by bringing together in brief compass a large volume of work of which the essential unity was perhaps unappreciated because it was scattered among so many and diverse reports and publications. As Chairman of the Kenya Agricultural Commission in 1929 I had been seized of the necessity of reforming the native methods of agriculture if the tribes were to be saved from reducing their reserves to a state of desert. Since that time Sir Albert Howard's farseeing work at Indore had offered a solution to the prime problem of maintaining the fertility of the soil under tropical and semi-tropical conditions. The growth of our knowledge of food accessories had indicated the causes of some of the defects of nutrition which do much to maintain many primitive peoples at so low a level of physique and health that they cannot take their due place alongside the white man's civilization, and Sir John Orr's pioneer work had showed how large was this factor of malnutrition among the African natives. I have therefore endeavoured, however summarily, to outline on a fundamental scientific basis the means by which the African tribes can be given a higher standard of living and be relieved of the pressure of over-population, of the incidence of much preventable disease, and of the imminent menace of the destruction of their land. It is always before my mind that this is very much a British responsibility, for we have definitely declared ourselves trustees for the natives of so large a portion of Africa. We are there neither to displace the natives nor to exploit them; actually we have to save them from themselves, for the intrusion of our Western civilization has a destructive effect upon the tribal cultures, whether we rate them high or low. There is room for the white man in Africa, he has much to gain there, provided he does his duty by its inhabitants.

I have had sufficient contacts with Africa to be aware of the imperfections of my survey; I have had to call upon many sources of information; in particular I have to thank Sir Albert Howard, the Hon. Alexander Holm, Mr. H. C. Sampson, and Professor V. H. Mottram for the help they have given. Again I owe much to Miss Schafer for her assistance with text, proofs, and index.

MERTON
November 1935

A. D. HALL

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THE MAINTENANCE OF FERTILITY

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THE MAINTENANCE OF FERTILITY

I CAN best set out my purpose in these lectures by a quotation from the Annual Report of the Medical Department of Kenya for 1934, by Dr. A. R. Paterson:

> 'From his experience, first as a doctor and secondly as a sanitarian, he may recite two facts, namely, that one major cause of ill-health in the African is a poor dietary, and that another is the insanitary conditions resulting from insanitary and wasteful farming.'

I shall discuss the means of improving native agriculture as the first step towards better health and a higher standard of living, and I shall deal with Africa because in that continent the necessity for action is great and the responsibilities are largely British.

The possibility that under continuous cropping the soil would ultimately become exhausted has always been before men's minds. We have on the one hand the popular idea of the fertility of virgin soils, accompanied often by the other idea that regeneration of the cultivated surface layer could always be effected by tapping the unexhausted layer below. But even before science had been applied to the question the practical man had learnt by experience that the fertility of the soil was a product of cultivation as well as an inheritance and that it resided in the surface. The farmer was chary of bringing up with the plough the subsoil, the gardener when he trenched the land was careful to keep the top spit on the top.

Nevertheless, it became evident that the maintenance of fertility was in some way dependent upon the method of farming followed. Some virgin soils evidently possess enormous reserves of fertility, like the black soils of Manitoba, which as Lawes and Gilbert showed fifty years ago[1] contained nearly one per cent. of nitrogen down to the fourth foot, as compared with a quarter of one per cent. in the first foot only in one of the richest of English soils. These black soils, to be found in many parts of the world, as in the Russian chernozem, are the virgin soils of popular

imagination, but even with them it becomes evident that under the sort of cultivation to which they were being subjected—e.g. in the Middle West the continuous growth of cereals like wheat and maize—their productive power is being worked out, just as some of the black soils in our own Fens are getting visibly thinner and giving place to the underlying comparatively infertile clay. Elsewhere, as has been latterly seen in the prairie states themselves, in Montana or Alberta, and again in Africa and Australia, land is found to become unproductive after a decade or less of cropping. It seemed pretty obvious that if the soil is only a reservoir of fertility, some of which goes to make up the crop which is removed, exhaustion must follow after a longer or shorter interval. Even a scientific man like Crookes in his famous address to the British Association in 1898 saw an eventual limitation and then a shrinkage of crop production because of the progressive exhaustion of the stock of nitrogen of the soil, nitrogen which existed there only as the residues of past vegetation, which was being removed with each crop that was taken away for food and was not being replaced by natural processes. I need not consider Crookes's remedy—the artificial production of combined nitrogen compounds which has since then passed from a laboratory experiment to a world industry, because even as he spoke science was beginning to learn about the recuperative agencies in plants and in the soil itself which are gathering nitrogen from the atmosphere and so continuously repairing the losses of which Crookes was so conscious. Indeed, had he taken a wider survey of the then existing agriculture he must have realized that some factor must be at work of which his diagnosis took no account. European agriculture has cultivated the same fields for two or even three thousand years, and though at the time Crookes was speaking they might seem to be dependent upon fertilizers and extraneous sources of fertility, yet a hundred years earlier our English land, before any importations of fertilizers began, was maintaining a steady production of which the index was about 20 bushels to the acre of wheat when this crop came round in the rota-

tion. Not a very high level of fertility indeed, but in the Far East, where an intensive agriculture had been evolved to meet a population density unparalleled in Europe, the land had been made increasingly self-sufficient for three or four thousand years. King[2] gives the following astonishing figures:

'The average of seven Chinese holdings which we visited and where we obtained similar data indicates a maintenance capacity for these lands of 1783 people, 212 cattle and donkeys and 399 swine —1,995 consumers and 399 rough food transformers per square mile of farm land. The population of the large island of Chungming in the mouth of the Yangtse river, having an area of 270 square miles, possessed, according to the official census of 1902, a density of 3,700 per square mile, and yet there was but one large city on the island, hence the population is largely rural.'

'When we reflect upon the depleted fertility of our older farm lands, comparatively few of which have seen a century's service, and upon the enormous quantity of mineral fertilizers which are being annually applied to them in order to secure paying yields, it becomes evident that the time is here when profound consideration should be given to the practices the Mongolian race has maintained through many centuries, which permit it to be said of China that one-sixth of an acre of good land is ample for the maintenance of one person, and which are feeding an average of three people per acre of farm land in the three southernmost of the four main islands of Japan.'

This sets out the question I propose to consider in these lectures; in many parts of the world the land is showing signs of exhaustion and is proving unable to support a growing population. Hence follow diseases arising from malnutrition, social unrest, and land hunger, eventually war and the disintegration of the cultural organization. On the other hand, in certain countries of older civilization, notably in the East, the land seems to be equal to producing food at a high level for an indefinite period. Is there a lesson to be learnt therefrom which will remove the threat of soil exhaustion? When a tribe or nation demands more land it is at least a temporary answer to teach it to make full use of its existing land, even though that may be only putting off the day when the pressure of population becomes insistent again at a new level.

To get the problem in true perspective we must begin by reviewing the elements of fertility, an old story perhaps now, but one we need to read in a special way. At the outset we must postulate water, for although its source is independent of the soil many of the operations of cultivation are directed towards conserving and getting full duty out of the rainfall, and the reckless treatment of the soil may turn an adequate rainfall to waste. There is a quantitative relationship, not a fixed ratio but one ranging from 250–400 to 1, between the water evaporated through a plant and the dry matter produced, and this imposes a limitation on the production of many areas with a low rainfall and no irrigation water.

Soil fertility proper is, however, conditioned by the presence of three main constituents of the compounds of nitrogen, phosphorus, and potassium. The two latter, the mineral elements, are derived from the basic minerals of the rocks out of which soils grow, and such losses as the soils suffer by their removal in crops have to be repaired from the same source. Some soils and their parent rocks are deficient in one or both of these constituents, so deficient as to constitute the limitation to production, and ultimately this limitation can only be removed by the bringing in of some extraneous supply.

Nitrogen is, however, the dominant element in plant nutrition, for though the others are no less indispensable the plant generally makes shift to get enough of them out of the soil if the supply of nitrogen and water is assured.

Now, the higher plants can only utilize compounds of nitrogen and cannot assimilate the free nitrogen gas of the atmosphere. Moreover, the earth's crust can have started with but a small stock of combined nitrogen, and every time organic material is burnt the nitrogen therein goes out of combination into the gaseous state. On such a basis there is no source in sight for either the original stock of combined nitrogen in the world's soil and living organisms, nor any adequate means of repairing the losses it suffers by conversion into the free gas. But just about sixty years ago one agent was discovered which is at work bringing nitrogen

into combination, in the shape of certain bacteria which live symbiotically in the nodules that are found on the roots of the leguminous plants. Plants of this family are distributed the world over and some members play a prominent part in the farming of every country, e.g. the clovers, peas, and beans. It is not surprising that this source of combined nitrogen should have remained so long unperceived, for it was only in the later half of the nineteenth century that Pasteur's work had begun to make people conscious that bacteria possessed functions and were active agencies in the organization of life. The practical man had been applying the principle involved from the beginning of time; the earliest records of agriculture tell us of the well-tried experience that the growth of crops like vetches or beans was the best preparation for a succeeding crop of wheat.[3] The bacteria associated with the leguminous crop gather from the air not only the nitrogen contained in the crop that is harvested, but much more that is either left behind in the roots or excreted during growth whereby the land is left richer in nitrogen than it was before. In one of the classical experiments of Lawes and Gilbert a piece of land sown with clover in 1883 produced crops which removed some 320 lb. of nitrogen per acre, and yet the surface soil at the end contained 175 lb. more nitrogen than it possessed at the start of the experiment. It will be found that all the systems of European agriculture, which have maintained the land in cultivation for many centuries without exhaustion though perhaps at no high pitch of fertility, are based upon a rotation which includes one or more leguminous crops at regular intervals, whereby the nitrogen stock is restored. It is this inclusion of the leguminous crop which differentiates the conservative rotation from the wasteful mining into the resources of the soil such as took place in the early exploitation of the Middle West by the continuous growth of maize and wheat. Many African settlers have found how quickly soil exhaustion can set in under repeated croppings of maize. An experienced farmer in Kenya found that after the eighth growth of maize the land would no longer produce a paying crop;

I have seen the land indeed almost infertile after a third crop.

The discovery of the nitrogen-fixing power of the bacteria associated with the leguminous plants did not long stand alone as the only example of such bacterial actions. In that case the host plant supplies the bacteria with carbohydrate by the combustion of which the bacteria derive the energy required to bring the free nitrogen into combination. There is a real partnership, for the host plant gets in return nitrogen that it requires for its growth. As Thornton[4] has shown, under adverse conditions the bacteria become parasitic and rob the host plant of its substance without giving anything in return. Though the organisms associated with the leguminous plants may be regarded as belonging to a single species, *Bacillus radicicola*, there exist certain physiological strains appropriate to particular groups of host plants and differing in their efficiency as nitrogen fixers. These differences are becoming of practical, even of commercial importance, for with the extension of cultivation of particular legumes on to land that has hitherto not carried that or a closely related species it becomes necessary to inoculate the seed with a pure culture of its appropriate strain, and such cultures are now prepared for sale. In England, for example, inoculation is necessary when introducing lucerne or soya bean into new areas.

The leguminous organism has little power of fixing nitrogen when grown as a pure culture without its host plant, but, as was to be expected, several other organisms have been discovered which can bring nitrogen into combination when living free in the soil. Of these the most significant is a large bacterium named *Azotobacter chroococcum* by its discoverer, Beijerinck. It may easily be isolated and shown to fix nitrogen by introducing a trace of almost any cultivated soil into a sterile nutrient solution without nitrogen but containing a carbohydrate (maltose is the most effective for experimental purposes) and some calcium carbonate to neutralize the acids also produced. As much as 9–10 mgm. of nitrogen is fixed for each gram of carbohydrate oxidized. The *Azotobacter* organism is widely distributed

throughout the world; it has been found in the fertile soils of every continent, particularly in the deep black soils, though only in soils possessing a neutral reaction and containing an appreciable amount of calcium carbonate.[5] Indeed, to the fact that this organism is only active when the soil reaction is neutral or slightly alkaline we must attribute the experience that the soils duly supplied with lime are the fertile soils of the world.

The noteworthy feature of the action of *Azotobacter* is that it provides the mechanism by which nitrogen can accumulate in soils which are not carrying a leguminous vegetation. In the absence of legumes mere plant growth, however long continued, cannot add to the stock of nitrogen, though the vegetation is allowed to decay and return to the soil the nitrogen it has taken out. But when the carbonaceous matter manufactured by the plant in the year's growth falls back to the soil it provides the source of energy for the *Azotobacter*, whereby to bring nitrogen into combination and so increase the stock in the soil. The classical example of this process is afforded by the area at Rothamsted, part of the wheat field, which has been allowed to run wild and acquire a spontaneous self-sown vegetation which has never been harvested or grazed. Initially poor in nitrogen, the soil of this area when examined many years later was found to have enriched itself by an amount approximating to 100 lb. of nitrogen per annum.[6] A similar area at Rothamsted, but situated on soil almost devoid of carbonate of lime, had in the same time only gained about half as much nitrogen.

It will be seen at once what bearing this observation has upon that characteristic feature of native agriculture in so many countries—*shifting cultivation*, the practice by which the cultivator clears a patch in the bush and crops it for perhaps a period of three years. He then abandons it for another clearing, and does not recur to the same land until a varying number of years have elapsed, during which the land accumulates fertility again and the weeds of cultivation die out.

To complete the scientific basis of these observations on

the accumulation of fertility as a result of bacterial actions when the carbohydrate material of natural vegetation is allowed to fall back to the soil I must refer to another series of experiments at Rothamsted made by Dr. H. B. Hutchinson.[7] He took one of the continuous barley plots which by long cropping without any nitrogenous fertilizer was in an extremely exhausted condition as regards nitrogen, though for many years it had been receiving phosphates and other minerals and it also contained a sufficiency of calcium carbonate. Half of the plot was treated with carbohydrate (sugar, in one case starch) at the rate of 1 ton per acre, which may be taken as fully equal to the carbohydrates contained in the year's growth of natural vegetation. To summarize the experiment, which extended over a period of six years, when the carbohydrate was applied in the spring its effect was negative, there was a definite reduction of crop. But when the application was made in the autumn there was an increase in the following crop, on the average of 37 per cent. The determining factor lay in the temperature of the soil following the application. At the time of the autumn dressing, September, the soil was still warm enough to permit the *Azotobacter* to get to work and fix nitrogen which became available for the crop of barley sown in the following spring. At the time of the spring application, however, the soil was too cold to activate the *Azotobacter*, whereupon other oxidizing organisms working at a lower temperature attacked the carbohydrate, but not being nitrogen fixers they had to obtain the nitrogen they also required from the small stock in the soil. As the barley was sown shortly after the application these organisms were thus competing with the barley for what little available nitrogen there was in the soil, with the result of a smaller crop. Further experiments confirm both conclusions, first that the nitrogen-fixing organisms require a fairly high temperature in the soil, and, secondly, that when active bacterial action is going on in the soil, breaking down vegetable matter which is not itself rich in nitrogen, the bacteria enter into successful competition with any growing crop for such reserves of active nitrogen as may be in the soil.

This latter observation has an important bearing on the variable results that have been obtained from green manuring. It may also be noted that in Dr. Hutchinson's experiments a parallel series on another plot, equally starved of nitrogen but also exhausted of phosphate, did not show any significant gain from the application of carbohydrate. The *Azotobacter* cannot work without a due supply of the mineral elements of fertility, notably of phosphoric acid and carbonate of lime, as other experiments have shown.

Having thus briefly discussed the scientific basis of the natural process whereby fertility is maintained in or restored to the soil, we may proceed to a consideration of the methods of farmers in the old settled countries of the world where intuition and experience have evolved methods of securing continuous production from the land without the menace of soil exhaustion.

In our own country it may be presumed that the earliest farmers practised a form of shifting cultivation, the influence of which may still be seen in the West and North, in the distinction between outfield and infield in the old Scottish farming, and in the Welsh custom of moving the arable cultivation from field to field round the whole area of the farm, most of which at any one time will be in grass. When no extraneous source of fertility is available, arable cultivation and continuous cropping with cereals is exhausting. But the fertility gradually returns when the land is left for a few years in grass, partly because of the natural clovers and other leguminous plants that spring up and partly because the roots and other vegetable residues that fall back to the soil provide material which enables the *Azotobacter* organisms to collect nitrogen from the atmosphere. At the same time the phosphoric acid and potash are also being added to the surface layers as they are brought up from the subsoil by the deeper roots of the herbage plants. It is not a high level of fertility that can be thus maintained, but it was sufficient for the small population and the low standard of subsistence then prevailing.

With the arrival in Britain of certain of the Teutonic tribes, presumably even before the Roman conquest, came

a more definite system of fixed agriculture which has left its marks upon the land even to this day. Many of these tribes, not however all, both then and in the later Saxon invasions, brought with them a form of land tenure which was widespread over Europe, and indeed seems to be part of the inheritance of a considerable section of the Aryan folk. This was the strip system of arable farming whereby the cultivated land was divided into three fields, one devoted to winter corn—wheat or rye, another to spring corn as barley or beans, while the third was left fallow. In each of these fields every member of the community possessed the use of a certain number of units of land, which he cultivated for the appointed crop and took the produce. Outside the three fields was an area of communal grazing. How far the tenure was originally communal is still a matter of dispute; at any rate in Britain it emerges in history as the manorial system in which there is an overlord owning the whole group of fields and waste, but subject to the customary tenures of the cultivators. The historical aspect is outside my consideration, but from the point of view of the conservation of fertility we find two crops grown for food, and thus exhausting, followed by one year of rest, when the growth of weeds would have some recuperative effect. In so far as beans were grown on the spring-corn field these would also bring about some recuperation. While there is evidence of some use of the live stock to restore fertility to the arable land by folding them there at night after they had been grazing by day on the waste, and at other times by confining them at night and afterwards collecting the dung for manure, yet these restorative measures were of small efficiency and the level of production that could be maintained was very low. Walter of Henley, writing in the thirteenth century, and another almost contemporary author, when the system was in full vogue, speak of threefold up to fivefold returns for wheat, rather more for rye and barley, if the crops were successful. We shall not be far out if we take for an index an average yield of 10 bushels of wheat per acre for a sowing of 2 to 3 bushels.

The pressure of population and the desire to get a cash

return as well as subsistence from the land gradually brought about a change of system—the enclosures, which, beginning in Tudor times and culminating perhaps in the eighteenth century, are now completed save for one or two examples of the old tenure which rank almost as museum pieces.[8] The communal farming was too restrictive of the powers of the individual to vary his cropping or improve his land; the act of enclosure re-parcelled the lands of the manor and gave each of its tenants a piece of land in freehold, proportional to the extent of the strips he had held before in the common fields. As the owner could now fence his fields he could begin to grow fodder crops for his live stock and to bring the resulting manure back to the land from which it had originated. At about the same time as the enclosures got under way, English landowners were coming into contact through the wars of religion with European countries in which still persisted some of the methods and the crops of the old Roman farming, which had possessed a far more skilful technique than the three-field system of the barbarians who swamped northern Europe. From Flanders and France were introduced root crops for stock feeding, and sown grasses, clovers, and lucerne; by means of which towards the end of the seventeenth century the eastern county farmers of England had evolved a routine—the four-course rotation, which with local modifications has dictated the order of British cropping down to the close of the nineteenth century.

In the four-course rotation the crop of turnips or other roots was followed by a crop of barley in which the small seeds were sown so as to give a crop of clover, pure or mixed, in the third year. On the sod of the clover ley ploughed at the end of summer the wheat crop came, whereupon the cycle was renewed again. Of the four years' produce only the wheat and the barley grain were sold or consumed away from the land, and their straw was trampled down to manure under bullocks receiving the roots and the clover hay. The covenants were rigorous against the sale of anything but the grain; thus the system was conservative of the fertilizing materials taken from the soil, while the

clover (alternatively beans) coming every fourth year was recuperative by reason of the nitrogen collected by bacterial action. The change to this system from the old open-field farming was accompanied by a considerable increase in production and in the level of fertility maintained in the soil. By the end of the eighteenth century we can gather from observers like Arthur Young and Marshall that the average crop of wheat was about 20 bushels per acre, and if the four-course system only gave two grain crops in four years instead of two in three years of open-field farming, the other two years were producing beef or mutton, instead of the entirely unproductive fallow in the third year of the old system.

How effective a leguminous crop can be in collecting nitrogen to maintain the fertility of the soil under continuous cropping may be seen from one of the Rothamsted fields, Agdell, which is cropped under the four-course rotation.[9] One of the plots has received no nitrogenous fertilizer since 1848, but is supplied with superphosphate, potash, and other mineral constituents. Taking the mean of the yields during the twenty years 1884–1903, a period beginning no less than thirty-six years after the supply of nitrogen as manure had ceased, the crops amounted to 38 bushels per acre of wheat, 20 bushels of barley, 10½ tons of swedes, and 33 cwt. of clover hay (alternatively in one year 28 bushels of beans), all removed, for nothing of the crop gets back to the land except the roots and stubble of the clover, wheat, and barley. On a parallel plot similarly managed but where the swedes were ploughed up and chopped in as some equivalent to the usual return of the farmyard manure resulting from the crops grown, the yields became 41 bushels of wheat, 29 bushels of barley, 12 tons of swedes and 38 cwt. of clover hay. Now this represents a higher level of production than was on an average being obtained from English land in the same years. All this production, which on an average permanently removed 38 lb. of nitrogen per acre per annum from the soil, was being maintained by nitrogen drawn from the atmosphere without any nitrogenous fertilizer.

The four-course system was in its way something to be proud of as an example of sound intuition, maintaining the fertility of the soil at a fairly high level when farming on a relatively large scale. It will be noted that the foundation of the system is the regular recurrence of the clover crop, gathering nitrogen both by the bacteria in the nodules on its roots and by supplying organic matter to the soil by the oxidation of which the *Azotobacter* organisms could fix further nitrogen, adding also a stock of humus whereby the texture and relations of the soil to water are improved.

At this stage in the history of British agriculture a new factor enters—the introduction of extraneous sources of fertility, the so-called artificial manures. Just about a century ago nitrate of soda began to be brought from the Pacific, bones from Europe or India; the new gas works began to provide sulphate of ammonia, a little later Lawes was manufacturing superphosphate from fossil animal remains. For the farmers of Britain fertility was also being imported in feeding-stuffs for our cattle—maize, linseed, and other grains containing nitrogen and some amount of phosphoric acid and potash. Our land was raised thereby to a new pitch of fertility, the 20 bushels of wheat per acre —the norm of the eighteenth century of self-contained farming, became 30 bushels per acre by 1870 and only price considerations prevented a still higher yield. The range and extent of the artificial fertilizers have been enormously extended, indeed as regards nitrogen have taken a new leap since the War has brought to such a pitch the methods of bringing the atmospheric nitrogen into combination. As part of the great war machine each nation under the new nationalism must maintain its establishments for manufacturing synthetic nitrogen products, for nitrogen is the basis of explosives as of fertility. The output of fertilizers in peace time can be switched over to explosives in war. British farmers are sometimes reproached for not making more use of the cheap nitrogenous fertilizers nowadays at their disposal, but for a long time world prices of agricultural produce have not encouraged expenditure. Instead, we see a considerable development of the natural

methods of restoring fertility on the soils of second quality, which are best under arable cultivation but can only grow cereals for sale. There it has become general to exchange the four-course or allied rotations, which have now become too costly in labour for the root crop, by an alternation of three or four years of grass and wild white clover, which in our climate is perhaps the most efficient gatherer of atmospheric nitrogen, with three or four successive cereal crops, for the growth of which little or no fertilizer nitrogen is then required, so considerable is the stock left behind by the clover and grass residues. This system of alternating a temporary ley, in which wild white clover plays a prominent part, with a short succession of cereal crops appears to have originated among the sheep farmers of the Border counties, but has become regular practice in the Midlands and south of England, where it has been found necessary to eliminate the turnip crop because of the labour involved. In this case the farmer is making use both of the nitrogen-collecting power of the wild white clover and of the further gain of nitrogen by *Azotobacter* working upon the basis of carbohydrate material left behind in the roots and stubble of the grass crop.

In the other countries of western Europe we see at work similar methods of maintaining fertility. The rotations adopted always contain a leguminous crop; the constituents of the fodder crops and the residues of the saleable crops are restored to the soil by the intervention of animals and their conversion into farm-yard manure. It is a conservative system, the ultimate draught upon the soil is light, and there are recuperative periods when a crop like lucerne occupies the soil for some years.

But the level of fertility thus maintained is not high, and the population that can be supported from the land is not dense. As I have discussed elsewhere,[10] in western Europe about $2\frac{1}{2}$ acres of cultivated land appear to be used in providing for one unit of population, even though in these countries a considerable proportion of extraneous fertility is imported as fertilizers or feeding-stuffs. Even in Denmark, perhaps the most intensively cultivated area, the

ratio of land cultivated to population supported becomes only about 1¾ acres. Of course, such a ratio is merely observational and has no necessary validity, conditioned as it is by unrelated factors of which the standard of living is the dominant one, because it determines the share that animal products bear in the dietary.

Taking another basis of calculation, Stribling and Ward[11] estimate that an emergency ration for a man could be obtained from 1·2 acres of cultivated land, 1·5 acres would supply an adequate ration at minimum cost, 1·8 acres an adequate ration at moderate cost, while a liberal ration would require 2·1 acres.

The standard of living dictates the wage rate, and upon the cost of labour depends the intensiveness with which agriculture can be pursued. In British agriculture, still more in American farming, the high wage-rate enforces economy of labour, consequently the land itself must be left to do the major part of the production except in so far as the costs of cultivation can be offset by increased technical skill and the use of machinery. The only intensive farming that pays its way consists in the production of semi-luxury articles commanding a high price. On the other hand, the higher the standard of living in the non-agricultural community the greater will be the demand for quality in the output from the land, for meat, milk, eggs, and other animal products, for vegetables and fruit. The poorer the community, the more it is forced to live upon cereals as the cheapest sources of energy; that is to say, the foods which call for least expenditure of labour in relation to their power of maintaining life. These considerations apply to the western communities where industrialism is highly developed, so that there exist alternative employments and extraneous sources of food, where by one means or other the standard of living is kept above the mere subsistence level. Among Eastern nations, however, and again among uncivilized tribes where no tradition exists to check the growth of population in order to maintain a standard of living, the number that can be maintained upon the land may rise up to and beyond the European density. For

example, in Kenya the Akikuyu are credited with a self-supporting population of 253 to the square mile, the Nandi may rise to 145 per square mile. This is in the main attained by a low standard of living, almost purely vegetarian, but the farming, even though it is *petite culture* with a lavish expenditure of labour, is of a low order and is wasteful of the resources of the soil. It is when we come to the Far East, to the old settled communities of Japan and especially of China, that we begin to find an astonishing density of population supported wholly by the land.

In China the conditions, both as regards rainfall and temperature, are admittedly more favourable than those prevailing in western Europe. It is possible to grow two crops a year without recourse to the hot beds and cold frames of the French gardener, but even allowing for this, the existing population can only be supported at an excessively low standard of living though the food may be adequate in amount, and an expenditure of labour and skill on crop production that is out of all proportion to that prevailing elsewhere. But the actual production from the land is high, many times that obtaining in Western agriculture, and the question arises of how soil exhaustion has been prevented and fertility maintained. There is no space for fodder crops for the maintenance of animals, for crops which are recuperative in themselves and conservative of fertility in that the greater part of the fertilizing elements they contain are restored as farm-yard manure. Such animals as are kept have to be fed on the waste of the crops grown for human consumption. The first feature to be noticed is that all human excretions get returned to the soil; this continuous source of waste is avoided, though, of course, at a large expense of human labour. The waste from this source in British and indeed in most Western agriculture is enormous. It has been calculated[12] that the average unit of population excretes per annum about 8 lb. of nitrogen, $4\frac{1}{2}$ lb. of phosphoric acid, and 4 lb. of potash, most of which reaches the sea under our water-borne sewage system. The loss of nitrogen can be repaired and the soil

possesses great reserves of potash, but the loss of phosphoric acid can only be repaired by fertilizers. A hundred years ago Liebig reproached us for this waste in no measured terms:

'England is robbing all other countries of their fertility. Already in her eagerness for bones, she has turned up the battlefields of Leipzig, and Waterloo, and of the Crimea; already from the catacombs of Sicily she has carried away the skeletons of many successive generations. Annually she removes from the shores of other countries to her own the manurial equivalent of three million and a half of men, whom she takes from us the means of supporting, and squanders down her sewers to the sea. Like a vampire she hangs upon the neck of Europe, nay, of the whole world, and sucks the heart blood from nations without a thought of justice towards them, without a shadow of lasting advantage to herself!'

But the distinguishing feature of this Eastern agriculture is not merely the conservation of the fertility excreted by human beings, it is the preparation of composts of earth, excreta, and of every kind of waste vegetable material that can be collected, including crops grown for the purpose. King[13] says:

'They' (the Chinese farmers) 'have long realized that much time is required to transform organic matter into forms available for plant food, and although they are the heaviest users in the world, the largest portion of this organic matter is predigested with soil or subsoil before it is applied to their fields, and at an enormous cost of human time and labour, but it practically lengthens their growth season and enables them to adopt a system of multiple cropping which would not otherwise be possible.'

The process is described from Shantung, where the compost is made in the house, earth being brought in from the fields.

'The compost pit was two-thirds filled. In it had been placed all the manure and waste of the household and street, all stubble and waste roughage from the field, all ashes not to be applied directly and some of the soil. Sufficient water was added at intervals to keep the contents thoroughly saturated. The fermented product is removed . . . to the floor of the court or where it is spread to dry, to be mixed with fresh soil, more ashes, and repeatedly turned and stirred to get complete aeration and to hasten the processes of nitrification.'

'Four months before . . . men had brought waste from the stables of Shanghai fifteen miles by water, depositing it upon the canal bank between layers of thin mud, and left it to ferment. . . . After these pits had been filled the clover which was in blossom beyond the pits would be cut and stacked upon them to a height of five to eight feet and thus also saturated, layer by layer, with mud brought from the canal, and allowed to ferment twenty to thirty days until the juices set free had been absorbed by the winter compost beneath, helping to carry the ripening of that still further.'

The purpose is twofold, to put all the materials through the preliminary processes of decay so that they reach the soil in a form immediately available as food for the plant, and secondly to take advantage of the nitrogen-fixing organisms of the soil like *Azotobacter*, whereby the purely carbonaceous materials of the waste also become a means of gaining nitrogen from the atmosphere.

It will thus be seen that while Western agriculture is chiefly dependent upon leguminous crops for their recuperative effect in maintaining the stock of soil nitrogen, the Oriental farmer also utilizes to a greater degree the direct action of *Azotobacter* and kindred organisms, and is thereby able to maintain his soil indefinitely at a much higher level of fertility.

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For a general discussion of the relation of bacteria to nitrogen fixation see also

WAKSMANN, *Soil Science*, 1926, xxii. 123.

II

THE REFORM OF SHIFTING CULTIVATION

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In the previous lecture I have discussed the principles of the two processes which are at work in nature whereby nitrogen is brought into combination. On them depend those permanent systems of agriculture which avoid the menace of soil exhaustion without needing recourse to extraneous fertilizers derived from fossil deposits or manufacturing processes. Even these latter do draw upon the ultimate capital of the earth's crust, since they are utilizing power derived from coal or oil.

I now propose to consider the application of these principles to certain features of native agriculture. Leaving out of account the nomad tribes which follow a pastoral life on wide areas of grazing land, the most primitive form of cultivation we find all over the world is defined by the term of 'shifting cultivation'. The tribe is in possession of an area of natural forest, bush, or jungle, within which its members clear a patch of its vegetation and burn off the trees and scrub. On the clearing the crops are grown for a period of two or three years, after which the soil becomes unproductive, either through temporary soil exhaustion or the invasion of particular weeds, whereupon fresh cultivation patches are cleared as before. The invasion of the old clearings by the indigenous vegetation is often rapid, and after a varying term of years sufficient fertility will have accumulated to permit of a return to cultivation.

A few instances will suffice to show how general is this system of farming.

'A favourite method of cultivation, among natives in the East at any rate, is what is called in Ceylon *chena*, in Malay *ladang*, in India *jhuming*, &c. The forest, or rather the trees in it below a certain girth, is felled and burnt, and various cereals or other crops are sown upon the land in the rains. On a rich, newly cleared land, these give a very large return for a minimum of work, and this method of cultivation is in consequence highly popular, until the country becomes too thickly populated to admit of it. After one to three crops the land is abandoned, and grows up in scrubby jungle, and may

again be chena'ed after 8–50 years. Vast areas of good forest land have been ruined in southern Asia by this destructive practice, and in most countries chena permits for crown land are now issued only under stress of very hard times and failure of the regular crops.' [1]

'A jhum is a temporary clearing made by cutting down the forest and burning it when dry. The usual rule here is to cultivate a jhum for two years and then abandon it.

'The chief and perhaps the only reason for abandoning jhums after the second year is the excessive growth of a species of couch grass which rapidly overspreads the field and smothers the crop. The people find it more paying and less troublesome to make a fresh clearing than to remove the weeds.' [2]

In Africa before the advent of the white man the practice was almost universal among the agricultural tribes and is only becoming replaced in a few cases. The following is from the Report of the West African Agricultural Conference:[3]

'The cultivator cleans the bush by felling and burning in the dry season and prepares the land for planting by making heaps about 4 ft. apart. He grows an early and a late crop each year and usually interplants the later crop before the early crop has been harvested. When the land is exhausted, which occurs in 2 or 3 years, he allows the farm to return to bush and does not again farm the same piece of land for a period of 3 to 7 years.

'Of the disadvantages of shifting cultivation little need be said. The agricultural history of many lands has shown that farming methods incorporating lengthy fallows have been followed only in the very earliest stages of development, and have been abandoned in favour of continuous cropping with the march of agricultural progress. Another point, which is of more importance to the community than to the individual farmer, is the fact that the ever-increasing search for new land results in the denudation of the virgin forest, which is replaced by a secondary growth of inferior quality, and is here and there completely ousted by the pernicious weed *Imperata*.'

Faulkner and Mackie write:[4]

'The practice known as shifting cultivation is almost universal throughout the whole of West Africa. Under this system the farmer clears a piece of land, crops it intensively for 3 or 4 years, and then allows it to revert to bush again until it has regained fertility, meanwhile clearing another area of bush land in order to make a new farm.

The resting period may be anything from 1 year upwards, depending on the density of the population and consequent demand for land; but the commonest period is about 4 or 5 years. The continuance of such a system depends therefore upon abundance of land, and hitherto this condition has existed generally in West Africa. But there are large areas in Nigeria where it no longer exists, and with an increasing population and an expanding demand for the produce of tropical countries, it can only be a question of time before a shortage of land becomes more general' (p. 43).

'Around each compound there is usually a small patch of land which is permanently cultivated, and is manured by the refuse from the compound. The main crops are grown upon the farm proper, which may be at some distance from the compound. The native farmer does not ordinarily farm the whole of his available land. Every year, part of it is under cultivation and part of it under bush conditions. When the cultivated land shows signs of exhaustion it is allowed to revert to bush again and a new piece is cleared' (p. 25).

Shifting cultivation is the system prevailing among the agricultural tribes in Kenya like the Akikuyu, the Akamba, and the Nandi. In Sir Morris Carter's report[5] will be found evidence of how the Akikuyu were eating into the forest bounding their area at the time white settlement began. Professor Ogilvie (British Association 1934) discusses the destruction of forests by the Awisa and Awauk tribes of the Upper Zambesi:

'The felled timber of the Awisa would take a generation to recover. Yet several district reports mention rest periods as short as four or five years; in others these are between ten and twenty, and in Barike thirty to thirty-five years.'

Among the South African tribes a similar system prevails:

'Fields were allocated to particular families, and generally speaking their boundaries were then respected by others. This was useful in preventing possible theft of crops. As a land became less fertile through overcropping it was abandoned and another applied for and given by the Chief or his deputy. This gave the soil a rest among a people who practised neither manuring nor rotation of crops; but it was a system that could only be maintained in a thinly populated country. Under present-day conditions it can no longer be maintained. Despite European influence, the use by Natives of the

alternatives of manuring and rotation remains exceptional, and more extensive education in these matters is overdue. In the absence of knowledge of better agricultural methods, the limitation of area is closely connected with the universal cry of the natives for more land.'[6]

Three points may be noticed in the practice of shifting cultivation. The burning off of the timber and other vegetation provides a considerable quantity of plant ash which is spread, and this adds to the soil potash and phosphoric acid, much of which had been brought up from the subsoil. The alkaline nature of the plant ash will also be helpful, the heat itself may be useful in destroying organisms reducing fertility and the seeds of weeds. Then the reasons for abandonment of the area are twofold, soil exhaustion and the invasion of weeds.

In any case, the system necessitates that the tribe and the individual shall have much more land available than is actually under cultivation. The cultivated area has to be multiplied by the number of years required for regeneration, a factor depending in the main upon rainfall but which may be anything from three to thirty years. It may be noted that among the claims being made by Kenya natives with regard to land taken up by white settlement are allegations that in certain cases they were paid only for the land in cultivation, ignoring the larger area incidental to the system and over which the individuals had rights according to the tribal organization. I say rights rather than property, for in this shifting cultivation the land is held communally, and as far as any idea of property in land exists, it inheres in the family or clan. A full discussion of the 'githaka' custom among the Kikuyu will be found in the report of the Kenya Land Commission, but the essence everywhere is that the married men of the clan have the right to apply to the Chief for an allocation of land, the use of which they then enjoy. The similar custom in Basutoland is described in a recent report:[7]

'Arable land is reserved for the use of married men or widows. Bachelors have no right to arable land under tribal custom, but occasionally receive it as a special favour. A man on marriage applies to

his Chief, and, if land is available, is ordinarily allotted three lands —usually scattered—the average area per land being 1½ to 2 acres, though there is no measure of area. By custom he is entitled to retain these lands during the lifetime of himself, his widow and his minor children, minority ending at marriage.'

The custom works as long as the land available to the tribe is large relatively to the population and that population is stable, but in so far as the population is increasing, a shortage of land inevitably sets in. The Basutoland report goes on to say:

'In the more congested areas a man may have to wait a considerable time before he can be given lands, and the proportion of landless men is increasing and is one of the reasons for going abroad for work.'

Now the increase of population in Africa has become very marked since the advent of European government, and in many tribes land hunger has developed already to an alarming degree. It is the fundamental cause of political unrest and threatens disastrously to break down tribal organization and native agriculture. The causes are obvious—the cessation of war and raiding under the European overlordship, and the efforts of the European medical officers who by degrees are introducing better hygiene and preventive measures against some of the epizootics.

A few figures will illustrate the growth of population. In the Union of South Africa the census returns for 1891 give a native population of 2,779,187 which by the 1921 census had almost doubled to 5,409,092. In the native reserve of the Transkei the census returns show a change from 262,705 in 1879 to 962,814 in 1921. In Basutoland the estimated population multiplied fourfold between 1875 and 1921, from 127,000 to 500,000. According to the Kenya Land Commission the Kikuyu population increased from 451,000 in 1902 to 489,000 in 1931, the density from 254 per square mile to 283 per square mile. At the same time it is estimated that there are now also about 110,000 Kikuyu outside the reserves. The Government statistician in Kenya estimates the annual rate of increase as between 1 and 1·5 per cent. Other evidence gives a rate of 0·8 per cent. in central

Kavirondo, 1·2 per cent. in northern, and 1·5 per cent. in southern Kavirondo as against 1·6 per cent. estimated for the Kikuyu. Amongst this latter tribe for special areas the estimate is 2 per cent., and as high as 3·8 per cent. among the members of a Catholic Mission. In Uganda the estimate is from 1·4 to 1·5 per cent., a ten-year estimate for the area is 1·9 per cent.

Now an increase of 1 per cent. doubles the population in 70 years, of 1·5 per cent. in 46 years, of 2 per cent. in 35 years. It must not, however, be supposed that such a rate of increase prevails all over Africa. Some tribes, like the Masai, appear to be stationary if not declining. Reports speak of the falling population in Northern Nigeria and of depopulation in the Belgian Congo and in French Equatorial Africa.

It is obvious enough that under the rate of increase indicated land hunger and something worse is inevitable, indeed, in many areas the land has already reached and passed saturation point. The Kenya Land Commission reports of the Kikuyu (p. 151):

'We have to face the fact that, unless remedial measures are taken, a state of general congestion is threatened within 30 years.'

Famine is never far away.

The Native Economic Commission write of the South African tribes:

'Normally, however, there was frequently a shortage before the new crop could be harvested. A paragraph on this subject from Bryant's "A description of native foodstuffs" (Pietermaritzburg, 1907) is true generally of primitive agriculture:

'"He" (the Zulu) "has inherited nothing of the saving instinct. No sooner are the fruits of the new season mature and permitted for general consumption, than he forthwith initiates a wholesale attack on them. This habit so materially reduces the amount left over for harvesting that after a few months his total store of food is at an end. In perhaps eight families out of ten there is a normal annual recurrence of severe dearth throughout the spring or early summer months of August, September, October and even later. During the whole of this period, members of all such families, children as well as adults, have to be usually content with but one

full meal a day, generally taken in the evening time. Very often I have known whole districts of children who got not even that. This, then, is the period when they have recourse to the amaThebe and the other herbs of the veldt."' (Native Econ. Comm., para. 23.)

The first necessity in these agricultural communities of Africa is a change from shifting cultivation to fixed agriculture, to a recuperative system of farming which will maintain cultivation indefinitely on the same land. As things are there is no little justification for Major E. S. Grogan's outburst before the Kenya Land Commission, coloured as it may be by the fact that Major Grogan's interests are largely in the forests to which shifting cultivation is the greatest threat:

'The African people have never established a symbiotic relationship with land. They are, in a strict scientific sense, parasites on the land, all of them. There are large portions of the East whose peoples have established a permanent equilibrium with the land, but these people are definitely parasitic on land. The only possible thing under their system would be if the quantities of people in relation to the areas of land are very very small, so that their points of "sucking" are reabsorbed into the great face of Africa and restored in the long processes of Nature.'

Twenty years or more ago Willis[7] wrote:

'Chena . . . is a vicious mode of cultivation and both wasteful and destructive. It should be put a stop to as soon as possible, at any rate on lands owned by the Government, and experiments to determine the best rotation of crops to practise upon the chena in private hands should early be put into practice. There is little doubt that the common contention of natives, that the land is too poor to stand continuous cropping, is untrue. The real reason, in many cases, at any rate, is that in two years it gets too weedy, and that it pays them better to chena a new piece of land.'

It is now necessary to consider how this system of shifting agriculture can be replaced by a fixed method of farming which will produce the same amount of food from a smaller area of land continuously cropped. The essence of the European system is a rotation which includes a leguminous crop recuperating the losses of nitrogen, and again the

keeping of stock in buildings so that the manure they make from the coarse products of the crops can be collected and returned to the land.

But at the outset we have to be a little careful about the insistence upon the growing of pure crops in blocks upon which a rotation can be founded. Native custom generally grows the food plants in mixture. In an African shamba one may expect to see maize and millets, with between them some beans, the variety depending upon the climate; cassava, yams, or potatoes, but no set plots of any one variety. Willis writes:

> 'Mixed garden cultivation . . . is perhaps the most common form of cultivation among the poorer villagers in the tropics. Though the yield in general is extremely poor, the mixture of plants gives one at least of the advantages of rotation of crops, the comparatively slow exhaustion of the soil, owing to the fact that the various crops take different proportions of the different elements of the food supply from the soil, and consequently the latter tends to become exhausted at a much slower rate, if at all.'

It is perhaps a more plausible hypothesis to consider that the roots of the different plants occupy different layers of the soil and so are not in direct competition, and again are developing unequally, so that they are not all drawing upon the soil fertility at the same time. There is some evidence even in our own farming, where soil exhaustion is not in question, that a mixed crop, like dredge corn (oats and barley) will yield more heavily than the average of the two sown singly. The practice is no longer common because the mixed corn is unsaleable. When legumes and cereals are grown intermixed some of the nitrogen collected by the legume may reach the growing cereal. The season may suit one crop rather than the other, hence the better one will predominate, and this factor probably determines the natives' preference for mixed cultures. At any rate, it has been found that some of the efforts the agricultural instructors have made in the reserves to replace the mixed cultivation have turned out indifferently, even if only because such failures as occurred in some of the crops were very manifest. Very careful study of the conditions should be made before

pressing the native to vary his customs; he is very slow to change, and any failure after a change will long be remembered. It is, however, possible to exaggerate the conservatism of the Africans in the matter of crops. Maize is an introduction that has only reached Central Africa within living memory, the ground nut, cassava, and sweet potatoes also came from America, yams are of oriental origin. All the same:

> 'These rules disapprove of "dangerous" innovations. Considered on a purely rational basis, the individual who tries a new method of cultivation may fail, and secure no crops at all, and may therefore become a burden on the community until the next season. As the matter appears to primitive man, one never knows whether tribal spirits will not be outraged by the new method; and outraged spirits may even give vent to their anger on the whole community, which allowed one of its members to engage in sacrilegious practices. Therefore the community stops innovation and, with it, progress to greater wealth.' (Nat. Econ. Comm., para. 25.)

Putting all these considerations together, the sort of cropping one wants to arrive at for native cultivation, either as a rotation or under mixed cropping, is one-half cereals, one-quarter beans and peas, and one-quarter roots and green vegetables. But even a rotation of this description, if the natives can be induced to adopt it with an adequate measure of cultivation, will only maintain a low level of production, because it does not provide for an adequate return of humus to the soil; and upon humus itself, not only nitrogen, the fertility of tropical soils greatly depends. The high temperatures that prevail result in very rapid oxidation of humus, and yet the humus determines both the water-retaining power of the soil, important when the rains are violent and widely spaced, and its resistance to erosion.

Green manuring with a leguminous crop has often been suggested as a first resource, but green manuring has proved itself much more adapted to the plantation cultivations and settler farming than to native plots. For example, low growing cover crops, like cow pea or *Crotalaria*, have proved of great value in plantations of coffee, tea, or rubber.

They are sown in strips between the rows of permanent trees or bushes, allowed to grow to a good development, but while still soft and green are then broken down and ploughed in. The same crops are being used as a preparation for maize. But green manuring has not been universally successful, and in any case requires careful timing and adjustment to the climate. We have the consideration that when growing, the cover crop may be competing seriously with the permanent crop for the water available, and that when used as a preparation it may leave the land too dry for the following sowing. Again, when the crop is turned into the soil, during its fermentation and decay, the bacterial activity set up draws heavily upon the soil nitrogen and other fertilizing elements and immobilizes them for the time being. Some interval must elapse before the material is, as it were, digested and becomes food again for the crops. Soft freshly growing vegetable tissue is usually rich in nitrogen and will ferment rapidly, so that it immobilizes the soil nitrogen less and for a shorter time. But as the green manuring crop grows older it becomes less nitrogenous and richer in fibre, whereby both the draught on the soil nitrogen is greater and the delay is increased before it can be liberated again as plant food. Under certain conditions of moisture, aeration, and temperature such as may be set up during a rainy season, bacterial change of the denitrification type may set in, with positive loss of nitrogen to the soil. These deoxidizing actions of the bacteria may be so rapid as on occasion to reduce the oxygen content of the soil gases to a point injurious to the roots of young seedlings, which become yellow and stunted. Beckley reports such happenings from Kenya, and I have observed a parallel case in greenhouse work with heat-sterilized soils during the period of very rapid multiplication of bacteria when the soil had been put into cultivation again.

While green manuring answers well enough under careful regulation as a cover crop to be turned in for the permanent crops like coffee, its use as a preparation for cereals requires adjustment to the climate and very often a fallow or incubation period of no crop.

In Southern Nigeria green manuring with Mucuna (*Stizolobium aterrimum*), Bengal bean, has been found effective for continual cropping; early or late green manure is dug in every year, but probably one early green manure plus one late cover crop in each three years is ample. But as yet a cover crop for green manuring that will also yield an edible bean has not been found. In Rhodesian maize growing, green manuring has been found valuable for the benefit accruing in the following season. While one would expect that legumes will provide the best crops for ploughing under as green manure, it has been found that on ground of very low fertility the leguminous plant nodulates indifferently and may function like any other plant requiring nitrogen from the soil and adding little nitrogen to the stock in the soil. The land may need preparing for the leguminous crop that is to ameliorate the soil, just as in Britain the application to a poor old pasture rich in organic matter of basic slag with its phosphate and lime induces an outburst of growth in the white clover plants which had previously remained stunted and barely visible. Of green manuring generally in Africa Beckley writes:[8]

'It is evident that in planning a green manure programme climatic conditions must be considered carefully. When the rainfall is well distributed and is ample to the needs of the crop, the problem is simple, but where the rainfall is chancy and badly distributed and just adequate, the problem becomes complicated. In Upper Kiambu the ploughing in of weeds is a common practice which gives very beneficial results. In the lower Riura and Thika districts the practice has often been detrimental. The weeds tend to ripen rapidly, and when turned under cause severe yellowing.'

However, in the main the question does not arise, because the African native is not practising a definite rotation into which a crop for green manuring can be interpolated, and a system can be devised more adapted to his methods of work and applicable to a limited area such as he actually cultivates at present for his maintenance. This system has recourse to the composting methods employed by the Chinese and Japanese, which has the twofold advantage of

providing manure immediately applicable to the soil even when occupied with a mixed cultivation, and also of making a more efficient use of whatever sources of fertility are available and of the capacity of the nitrogen-fixing organisms.

We owe the modern scientific development of the composting method to Sir Albert Howard,[9] who at the Institute of Plant Industry, Indore, attacked the fundamental problem of obtaining a continuous and adequate supply of manure for the small Indian cultivator, whose difficulties are the greater because of the general use of cattle-dung as fuel. Howard took as raw materials soil, earth scraped up from the surface of sheds in which cattle are kept, where it has regularly to be renewed, alkaline earth when available, and wood ashes to supply the bases, and then all the organic waste material—straw, weeds, leaves, &c., that can be collected, either on the cultivator's garden or elsewhere, especially such leguminous material as could be grown for the purpose on any land not actually in productive crop. I need not go into the actual details of Howard's process, which depends upon the construction of a series of shallow pits in which the preparation goes on. The heap is built up in due proportions and with regulated watering, a certain amount of material from a previous pit in an active stage of fermentation being added as inoculation. Howard distinguishes two biological stages in the breakdown of the vegetable waste, the first carried out by the soil fungi and initiated by the inoculation from a pit in which the fungous fermentation has just passed its full development. The mass of compost requires to be turned three times and re-watered at regular intervals, and there is a second inoculation to activate the bacterial process from an older pit that has reached this second stage of fermentation. The intervals between turning and watering and the duration of the process depend upon the season and the prevailing temperature, but the result is a comparatively dry fine earth rich in fertilizing materials, in which all trace of the original vegetable structure has disappeared, and which can be applied to the soil for the immediate use of the crop. As the Indore process was originally described,

it obviously called for a considerable amount of labour of an intelligent character, capable of carrying out a routine with nicety and perseverance. Such labour is obtainable in India, but cannot be expected from the African in his present stage of development. However, the methods described by Howard and Wad could not fail to attract attention in all tropical countries where the necessity of maintaining the humus stock in the soil is so insistent, and experiments were initiated to adapt the methods to African conditions. I believe the first trials were made by Major Grogan on his coffee estates in Tanganyika, and were so successful that the method rapidly spread to other coffee growers in Kenya and on the Government Farms. In Bulletin No. 9 (1934) of the Kenya Agricultural Department the chemist, Mr. Beckley, describes the modifications of Howard's process which have been successful in converting into manure of value normal agricultural waste such as straw or maize stem and even much more difficult materials like the pulp from the fermentation of coffee berries and sisal waste. But these are methods for large-scale farming and the plantation industries; of more importance to the question I am considering are some experiments, also made in Kenya by a District Officer, Mr. H. E. Lambert, adapting the Indore composting methods to the conditions prevailing in the native reserves. Simplification was the first essential, and in Mr. Lambert's method the vegetable waste is collected daily and stacked with a little watering until the pit can be started. The pits, as at Indore, were 30 × 40 feet and 18 inches to 2 feet deep, and in order to avoid over-compacting are filled up from one end in sections. Beginning with a layer of the waste 2 inches thick, this is moistened by a thick sludge made by stirring up collected cattle and goat dung, wood ashes, and a certain amount of earth with water, the more wood ashes the better. Layer by layer, and section by section, the pit is filled up, the whole being finished off in one day, this being the day of the week on which all subsequent operations will recur. The pits are kept in units of four, i.e. if more than four pits are required the four Monday's pits will be followed by four Tuesday's

pits, and so on. The four pits in the unit are charged at fortnightly intervals so that each is in a different stage of development and is discharged in succession.

The subsequent operations are simple, and recur only once a week, always on Monday, for example, with the Monday's pits, e.g. watering on 2nd, 4th, 6th, and 8th Mondays, turning the heap on the intermediate Mondays. On the ninth Monday the fermentation is completed and the friable mass is removed and stacked alongside for another four weeks, after which it can be put through a riddle to take out any coarse undecayed material, such being thrown back into the pit. It has been found unnecessary to prepare the urine earth employed in the Indore process, as it is more difficult material to procure in Africa, where the cattle are rarely kept under cover. On the other hand, plenty of dung is available, for there are abundant live stock and the dung is not burned. Inoculation may also be omitted, though some officers consider it accelerates the process, but if practised one inoculational charging is made with material from the pit that was started a fortnight earlier, and the second inoculation is made at the first turning, again from material that is a fortnight earlier. As far as the present somewhat limited experience goes, this extremely simple process, easily intelligible and involving a routine within the capacity of the agricultural tribes, is entirely adequate to provide a supply of manure that will maintain the soil at a much higher level of fertility and production than prevails under shifting cultivation. In a private communication to Sir Albert Howard, Mr. Lambert writes of it:

'The results were unquestionably excellent from the agricultural point of view. I never managed to get the compost analysed, but the results of its use in vegetable, flower and banana gardens and in cereal fields were remarkable. I am not so sure that the Medical people would be so satisfied. I found that when the Indore process as adapted to Embu was followed carefully temperatures attained were high (approximately the same as at Indore) but there were occasional instances for which I couldn't entirely account, when temperatures reached were scarcely satisfactory to the sanitarian,

though I never personally found any tendency to fly-breeding or noticed any unpleasant odour. There were certainly some differences between Embu and Indore in the rapidity of the onset of intense fermentation. The high temperatures after the change and after the first turn were rarely achieved so quickly at Embu. But agricultural results were uniformly excellent.

'You ask me to what extent the method has been taken up by the natives. I'm afraid I have to be very disappointing in my answer. A very great interest was shown by certain Chiefs and others and my own garden boys almost fought one another in their haste to get the compost into their respective spheres. But the ordinary agriculturist has not taken to the method, not because he has any objection to the method as such, but because, generally speaking, he has neither the education nor the need to use organic manures (or any manures) at all. Shifting cultivation is still the vogue. But the pressure on land will alter all this, in some places rapidly, and the Indore method (which is being preached far and wide and practised in many District Headquarters, Local Native Council Farms, European estates, &c.) is ready for him when the native wants it. Personally I have no doubt that the African will have Indore to thank for the solution of a problem which, though not pressing at the moment, will become increasingly so in the future.'

It now remains to consider the completion of the composting process by including in it the utilization of the human excreta from the family of the cultivator. I need not stress the importance from a sanitary point of view of a safe and economic method for the disposal of human excrement in tropical countries, especially when the native population begins to become as dense as it is with some of the African tribes. Paterson in Kenya has conducted a campaign for the construction of latrines in native villages as one of the most important factors in reducing the incidence of disease. If disposal by composting can also be made a means of restoring fertility to the soil, this becomes an added argument in its favour. The actual fertilizing elements contributed by the excrements of an individual are not great, but the active nitrogen of the urine does supply the necessary starter to bring about the rapid decomposition into humus of the other vegetable wastes included in the composting process, and at any rate the return

to the soil of so large a proportion of the phosphoric acid of the food does mean saving the element in which most African soils are deficient. We have the long-standing evidence of Chinese practice that such composting is a truly sanitary method of dealing with the refuse from a dense agricultural community and that it can maintain the soil at a high level of fertility. Apart from Chinese custom, the disposal of excreta by the composting method has been worked out practically by Jackson and Wad[10] at Indore, following upon the suggestion of the previous Director, Sir Albert Howard. I must refer those interested to the original paper for the details of the method they have adopted for the disposal of the night soil of the Residency area, of a municipality of 60,000 persons, and of the cantonments of Indore. The process is of the simplest, involving only the construction of trenches in which the night soil and refuse is spread with vegetable refuse in alternate layers, 3 or 4 inches thick, which are turned at intervals of four–eight or eight–fifteen days after charging, with watering as required. The process is complete within four to eight weeks from charging, according to the temperature and nature of the mixture; the material is then in good condition to go on the land and can safely be stored. There is no odour or nuisance and the rise in temperature in the early stages is sufficient to destroy fly larvae and doubtless both helminths and dangerous bacteria in the excrement.

I am informed that the natives of the Bantu tribes have a deep-seated, almost religious, objection to handling night soil in any way and would refuse to utilize excreta even when they can be induced to set about the preparation of a compost for their crops. Doubtless it will require both time and much education to overcome this and other prejudices; at the best the creation of a new tradition must be a slow process.

I would not pretend to suggest details of working methods suitable to African conditions, they can only be worked out on the spot, but the principles are beyond question and it cannot be doubted but that composting will supply to the African native a means both of maintaining the fertility of

his land under a system of fixed cultivation on a limited area and of safeguarding the sanitary condition of his habitation.

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III

OVERSTOCKING AND SOIL EROSION

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So far I have only been considering native agriculture from the point of view of replacing shifting cultivation by the continuous cropping of a smaller area, as a means of providing for the maintenance of the tribe and of relieving the pressure of population which is bringing the threat of famine. Native agriculture for sustenance is, however, always being invaded by the desire to grow crops for sale, crops which have been introduced by white settlers and traders. In Rhodesia, for example, the trade in native-grown maize is considerable, as it is in Kavirondo; cocoa has become important and has considerably altered the farming of the Gold Coast; native-grown cotton has become a valuable export from Nigeria and Uganda, ground nut from tropical West Africa; coffee is produced by the natives of Uganda, Nyasaland, and Tanganyika, and is now being opened to the natives of Kenya. Wattle has been valuable in all the South and East African Reserves, both as a sale product and for fuel, and because its growth is helpful against soil erosion. Even potatoes have become articles of export to India. In some cases, in West Africa in particular, the crops have been introduced by the missionaries, by the efforts of the Agricultural Departments and of traders. In Rhodesia, Nyasaland, Tanganyika, and Kenya, where plantation industries and white settler farms are more general, the natives have learnt how to grow crops for sale when working as labourers, and have carried the cultivations back to their own land. While the provision of food for maintenance, and that on a better standard of living, is still the fundamental necessity throughout Africa, it is to be expected that the participation of the natives in production for export will increase and that they will be more and more attracted to the use of their land as a means of earning cash, which will of itself improve the standard of living and incidentally will increase the demand for manufactured goods. The administration again often considers

that the introduction of a saleable crop is the best way of securing more intensive farming by the natives, as it is of providing for taxation. For example, Mr. C. F. March,[1] writing of the Nubas, an isolated tribe in the Nuba mountains of the Sudan, which was much given to fighting:

'About twelve years ago . . . the Government decided that the least expensive form of procedure would be to try to increase the interest of the inhabitants in agriculture. . . . The introduction of a cash crop (cotton) appeared to be the solution.'

At times this commercial farming results in the neglect of the traditional food crops. C. G. Hansford[2] writes of the cotton crop in Buganda and Busoga:

'The growth of the industry has been assisted by economic and other pressure upon the population. Many cases still occur of natives regarding the cotton crop as being chiefly grown to enable them to meet their liability of taxes in cash.

'In the "banana areas" of Buganda and Busoga, most of the cotton is grown separate from the banana fields and the two cultivations of bananas for food and cotton for cash bear little relation to each other.

'Of recent years there has been a marked deterioration in the general standards of cultivation of the main food crop, the banana, in Buganda.'

It is to be remembered also that there are industrial areas in Africa which have to be supplied with food, like the mining districts of Northern Rhodesia, the Katanga, and the Gold Coast. The towns that are growing up, even the plantations themselves, are not always self-supporting in the matter of food. It is beside the point here to consider how this native production is to be organized, how far co-operation and the setting up of central plants for processing and grading can be initiated. The point is that both farming for maintenance and for production for sale rest upon a foundation of proper soil management, and the methods we have been considering for stabilizing and increasing the fertility of the land apply equally, even more cogently, to industrialized farming.

One point, however, does require consideration, how far the change over to a fixed instead of a shifting agriculture will affect the conditions of native land tenure and tribal

custom. It has already been indicated that generally throughout Africa there exists no private property in land; the control of the land resides in the chief of the clan, the rights of the individual are customary, he is entitled on marriage to the allocation of an area of the tribal land for the use of himself and his family. Fixed cultivation tends inevitably to substitute some more permanent bond between the native and the land he is cultivating, something in the nature either of property or of tenant right. More especially is this the case when the cultivator for sale ventures on a long-standing crop, coffee or cocoa for example.

Under the old custom permanent trees, like oil palms or wattle plantations, were tribally owned, the produce was shared, with certain privileges for the chiefs. Herein lies a momentous problem for the administration, which has to walk warily and with very full knowledge of native custom and conditions, lest it inflict permanent injustice on the majority of the population. It is not a problem peculiar to Africa, but one that has had to be faced everywhere as the conception of private property in land had to be developed out of a customary agriculture. In England a more primitive and communal custom that crystallized into the manorial system was converted by the enclosures into several ownership; in the Highlands of Scotland, as late as the eighteenth century, the lands of the clan passed imperceptibly into the private property of the chiefs and headmen.

The history of land settlement in India provides many examples of the difficulties attending the creation of property in land, and of the dangers attending premature action before the native custom is properly appreciated. There is plenty of evidence that in Africa the tribal ownership of land is steadily being impaired.

'Concomitant with the enclosure of lands and the more intimate relationship between black and white have come marked changes in the social organization of the Bantu people, the passing of the system of communal tenure of land, and the rapid growth of individualism. . . . Basutoland, the Transvaal, and Zululand remain on the whole true to the old tribal system, whereas the natives in the Transkei and Natal are rapidly tending towards individualism.'[3]

From the other point of view we learn how the establishment of cocoa-growing among the natives of the Gold Coast has been followed by the creation of private ownership in the native plantations. There the change has been brought about equitably and by custom, but it has not always been so simple nor so just. H. B. Thomas[4] describes how in 1900, following the British occupation of Uganda, customary landowning among the Buganda was exchanged for freehold ownership. The settlement legally divided about 8,000 square miles among some 3,700 owners, it extinguished the old 'butaka' tenure, and created a general population of rent-paying tenants. Grievances inevitably followed such a hasty and formalized interpretation of the chiefs' position in the old tribal custom, and for its rectification a law giving the tenants security of tenure was passed in 1927.

Among the Kikuyu again we learn that in many districts the density of population has already become so great that shifting cultivation is no longer possible, the githaka custom is breaking down and something like personal possession of the land is beginning. In one case at least a native chief was given a freehold title to a considerable area of land in compensation for the displacement of his family or clan by white settlement. On this area the members of the group now work for him as paid labourers.

Here, then, is a considerable and pressing problem, for with the break-up of the old custom the authority of the chiefs is impaired and the social organization is endangered.

> 'Tribal conventions necessary to the morals and morale of the individual and the group may be destroyed before other conventions have been established in their stead.'[3]

It is to be remembered, too, that in areas where white settlements exist the natives are very nervous about the title to their tribal lands and apprehensive about any changes. In Kenya even the declaration that the title to the native reserves resided in the Crown, other than those of the Masai, which had been defined by treaty as inherent in the tribe, however much a legal fiction, has caused

apprehension (Kenya Land Commission). Here, however, I need do no more than indicate that land tenure is inevitably one of the questions bound up with the improvement of native agriculture, one too that is intimately concerned with the preservation of tribal customs and discipline.

I now come to a much more immediate problem, and that is the stock-owning customs of the majority of the African tribes. The Bantu, who are the chief agricultural race in Africa, are at the same time breeders of live stock —cattle, sheep, and goats. In the main they do not use these stock for food purposes; they drink milk to a limited extent, but eat meat only on ceremonial occasions; the hides and skins are dressed for sale and for clothing. Since the British occupation has put an end to warfare and raiding, these live stock have multiplied enormously in numbers and constitute the chief source of the demand for more land, far more than the requirement for increased cultivation. Almost everywhere there is serious overstocking, to the point of endangering the land itself.

The difficulty of the situation lies in the fact that among the Bantu cattle enter into tribal custom and religion. According to the custom, called 'lobolo' among the South African tribes, cattle constitute the chief element in the dowry which has to be paid for a wife. At the marriage ceremony some cattle are slaughtered and eaten as part of the ritual. As the women do most of the farming work, the wood and water carrying, the possession of more than one wife is desiderated, the limitation being the increasing amount of 'lobolo' now demanded. While sheep and goats are also included in the dowry they are not regarded in quite the same way as cattle. 'Sheep and goats are not affected by the custom of "lobolo" nor are they regarded to the same extent as an almost religious trust.' On the fundamental importance of 'lobolo' in the organization of the African natives the following extracts from the Report of the Native Economic Commission (704, 705, 711, 712), are eloquent:

'Lobolo has contributed much towards preserving tribes and keeping them intact, and is continuing to do so in the stage in which they are found to-day. The whole social structure of the Abantu rests

largely on lobolo, since it is an integral part of their life; the social life of families is concentrated round lobolo. Through it, intertribal relations are established by the marriage of Chiefs and of their sons and daughters with persons of the blood from other tribes. In the same community it establishes an even closer bond, between various family groups. The tribe is a "large family" consisting of an organized community of families; and marriage is exogamous. Lobolo cannot be overlooked in relation to the social and juridical status of both man and woman, more particularly of the woman: it upholds the worthiness of the woman in society, and is a spur to the man to be a person of status and so ensure his social position. The laws governing tribal life are mostly the laws governing family life.'

'Marriage is fundamentally a family affair; and among the Abantu it is this predominantly. Among them it is the family which brings about marriage, concludes the contract, arranges all, and pays all. The compact is solemnly sealed through the medium of lobolo, which constitutes a warranty on the part of the bridegroom that he is "no longer merely playing (dlala) but is in earnest", and is a token of his acknowledgement of his obligations. Moreover, in many tribes it ensures the maintenance in certain contingencies of the bride by her father or guardian. On the part of the bride it constitutes an acceptance guaranteeing wifely conduct. The principle underlying these bonds on husband and wife is the keeping of the family intact. Thus lobolo determines the validity or otherwise of the marriage, and thence the legitimacy or otherwise of children.'

'All religions have a social colouring, and among the Natives the *societas* is *religiosa*. The tribe is a social as well as a religious community, and so is the family. Most usages of Natives are social-and-religious, or religious-and-social. Thus in so cardinal a matter as marriage a religious ceremony must be observed to solemnize it, to mark the going-over and giving-over of a member from one socio-religious group to another. Therefore the main transaction connected with this, that which makes it legally valid and confirms and seals it, namely the passing of lobolo, must be grounded and rooted in the religion of the groups concerned. It is indeed a religious transaction. As one witness said, "Lobolo is to the Natives a religion". It is not a matter for individuals: it is a matter for family groups, for tribe, or for nation, depending on the status of the contracting parties and following the usages of the society to which they belong. Hence the people want to see the living cattle. According to the present-day conception of the Abantu, it is the beast alone which has actual value as lobolo: all substitutes are inferior, for proper religious significance

must be imparted to the transaction in full measure. "Real wealth is not money, but cattle" said John Dube pointedly. That is why Natives turn money into stock. The religious worth represented by the beast must obviously be taken into account: for the ceremony is not completed by the handing over of the cattle to conclude the contract; in addition beasts are slaughtered, in keeping with recognized ritual, in order to give a religious seal to the contract and to the alliance. Even non-tribal Natives acknowledge, as they do by their conduct, that money is here *infra dignitatem*; but these may execute the contract without cattle, for they have largely abandoned their tribal usages.'

'The only true wealth among the Abantu, at least since they became pastoral people, has consisted of cattle and other stock (goats and sheep included). To this day most natives take this view of cattle. Land-holding is naturally foreign to them; that is a development of later date, which appears to the Abantu as an aping of the individualistic European; but cattle, many cattle, is real wealth. It is this kind of wealth that determines the economic status of a family, for there is no possession to compare with it. A beast is "our" beast; the sense of possession is shared by all members of the family, and eventually by the whole society. Lobolo is then a gauge of the family's economic position. Many cattle bespeak many wives, and many wives a large family, adding strength and worth to the community.'

In a general way it may be said that the status of a man, especially of the chiefs, in any of the Bantu tribes is largely determined by the number of cattle and other live stock he possesses. In one sense they are currency (compare the Latin *pecunia*) and are preferred to money, for, as one chief told me, 'Money does not breed and may get stolen or burnt.' The owners are indifferent to the quality of the stock; numbers alone count. Consequently, as no sort of segregation nor culling of the males is practised, the majority of the stock are veritable weeds and, in the state of semi-starvation in which they are living, are of little value for meat; in ordinary commerce the hide alone would be paid for. Sales, however, outside the reserve are few. Besides the unwillingness of the Bantu tribes to treat their stock as business, access to markets is difficult, sometimes by reason of distance, sometimes on account of veterinary regulations forbidding the movements of stock outside their

own areas. For it must be remembered that Africa is the home of many of the most dangerous and infectious epizootics—East Coast fever, Rinderpest, Pleuro-pneumonia, Piroplasma, and Trypanosomiasis. The European veterinary officers carry out an immense programme of immunization and vaccination, but under the conditions they can advance but little towards clearing out disease, and often their efforts are only adding to the number of useless stock. Only a few of the pastoral tribes, like the Masai, are beginning to show interest in selective breeding.

A few quotations will illustrate the dangerous extent to which live stock numbers have grown in Africa. From the Report of the Native Economic Commission dealing with the South African tribes:

'Thus the purely economic conception of cattle held by Europeans is entirely disruptive of the religious ideas of the Abantu. Their conception of cattle has become under present-day conditions one of the most far-reaching anti-economic inheritances of the Native. It lies at the root of a great deal of the dissatisfaction about land. . . .' (Para. 34).

'With the exception of certain parts of Zululand and Pondoland, every Native area is overstocked, and this overstocking will continue as long as Native cattle-holding rests primarily on a religious rather than an economic basis' (Para. 74).

'The following increases are shown as between the years 1918 and 1930:

	1918	1930
Cattle	707,315	1,716,836
Woolled and other sheep . .	2,272,326	3,931,661
Goats (Angora and other) . .	1,026,653	1,203,942
Donkeys	4,719	10,535
Horses	80,382	138,343'

(Para. 272).

The Kenya Land Commission (1933) reports (p. 494):

'1983. With the introduction of British Administration, veterinary measures for the control of these diseases were introduced, and by 1920 the cattle population had increased to an estimated total of 3,000,000. Up to that year signs of overstocking and consequent deterioration of land and cattle were hardly noticeable.

'1984. We have heard evidence that 20 years ago the Kamasia reserve was still a well-grassed country, and the Suk were burning their grazing areas every year with a view to controlling the grass. Also, to the personal knowledge of two of our members, the conditions in the Kamba Reserve and in the drier parts of the Masai Reserve were still tolerable.

'1985. Now, in many parts where there used to be grass, there is nothing but bare earth, and although we do not agree with some witnesses that there has been a decline in the annual rainfall, there is no doubt that, owing to the denudation of the soil, such rain as falls quickly runs off the hard pan which has formed, or evaporates, and is of far less benefit to the land than it was when the soil was covered with grass.

'1986. Another serious factor, pointed out to us by several witnesses and corroborated by our own observation, is that areas which used to be open grass plains are now being overgrown by dense thorn bush, which absorbs the moisture and plant food at the expense of any grass which may be endeavouring to re-establish itself.

'1987. Probably about 1920, the main stock areas of the native reserves had attained their optimum carrying capacity, and although fully stocked, were not overstocked. Since then the cattle population has, according to the evidence given before the Commission by the Chief Veterinary Officer, increased to about 6,000,000 or, roughly speaking, doubled itself in the last twelve years.

'1988. We have therefore, at the present moment, a preposterous state of affairs in the Colony, which can be summarized as follows: a human population of under 3,000,000 owns about 6,000,000 cattle, and probably many more sheep and goats. The large majority of that population has little or no milk for the use of themselves or their children during the dry months of the year. In many parts of the reserves, the cows do not produce sufficient milk even to feed their calves. Meat consumption is far below what would be considered the necessary requirements of the natives; and annual sales, apart from sheep and goats, to outside markets are not more than 20,000 beasts and a negligible amount of ghee.

'1989. In the midst of plenty, the natives in pastoral and semi-pastoral areas are, in fact, living under conditions of extreme poverty. After paying their taxes (which they are not always able to do) money for food and clothing is practically non-existent, and will continue to be so until they turn the products and increase of their large herds of stock into some more useful and fluid kind of currency.

'2000. But there is another side to the picture which we prefer to

envisage. The native reserves of Kenya contain some of the finest dairying land in the world, and should be capable, not only of providing ample supplies of meat and milk for their inhabitants, but also of exporting large quantities of dairy produce.'

From the Kenya Land Commission I extract the following reports concerning the Kamba reserve (p. 29, para. 119 et seqq.):

'In the Kamba reserve there are over a million acres, of which 32,000 are under cultivation. Mr. Scott Little estimates that the Reserve contains 190,000 cattle, with 57,000 calves, though he estimates its grazing capacity at no more than 60,000 head. There are also 260,000 goats and 50,000 sheep.

'A journey through the area east and south of Machakos reveals that over large stretches of hill-sides vegetation has been almost wholly removed. The soil has been eroded down to the subsoil and its removal will continue at an ever-increasing rate. On less steep slopes and on better land, vegetation still persists, and though the Wakamba are primarily a pastoral tribe patches of cultivation are in evidence. But even there grazing has been so persistent that the ground is all beaten down into little stock-paths and has become in its turn open to erosion.

'It is not too much to say that a desert has already been created where grazing formerly was good, and where even cultivation existed, and that the same desert conditions are steadily approaching the land carrying stock and cultivation. The droughts of the past two seasons have intensified the rate of destruction and are causing grave disturbance in the tribe. Though additional grazing has, in fact, been provided for the tribe on the Yatta Plains, the Commission is informed of several movements to take stock out of the desolated country to the Crown land to the north of the Reserve, and land to the south-east of the Nyeri Native Reserve and to the Giriama country near the coast. This illustrates the unrest that is caused in the tribe by the destruction of the grazing within their own country.

'Mr. Silvester, the District Commissioner at Machakos, states that about 150 bags of maize a day are being imported into Machakos and each of the neighbouring stations upon which the Wakamba are living. The members of the tribe seem for the present to be able to subsist by buying food with hoarded money, but whether the supplies will last out until a new crop can be harvested is a matter on which the Commission has no information. Meantime there is very little evidence of any attempt to sell stock and it has been stated that

members of the tribe have been known to die of starvation rather than to kill any of their stock for food.

'The Wakamba solution of the difficulties of this tribe is that they should be given more land. But there is no considerable area now open, and even if new land could be found the process of destruction would only be renewed. No space would be big enough for the Wakamba so long as they only aim at increasing the number of their stock without utilizing them.'

The most serious aspect of overstocking lies in the destruction of the soil that is being produced. In some cases it may be no more than the replacement of vegetation of grazing value by worthless or injurious weeds.

'Overgrazing has so far failed to destroy the grazing on the lower levels, up to say 7,500 feet; but above that level the concentration of stock driven out from the lower levels has resulted in the replacement over some hundreds of thousands of acres of the grass by the almost inedible *Chrysocoma* commonly known as "bitter Karoo". . . . Another result of overgrazing has been the spread of a plant of the ragweed family known as *Senecio* which is fatal to horses and has caused heavy mortality in some areas' (*Financial and Economic Position of Basutoland*, p. 6).

The greatest danger, however, lies in the fact that overgrazing may so destroy the vegetation and bare the surface that soil erosion sets in. In all tropical and semi-tropical countries, even where the total rainfall is low, torrential rains occur. Normally the vegetation breaks up the violence of the storm and retains some of the water; the roots hold the soil together, but wherever the surface is bare the flow gets concentrated and will begin to attack the soil at any break in the surface, with the result that the soil itself begins to wash downhill with astonishing rapidity. Of all live stock the goats are the worst offenders; they graze more closely, on bushes as well as on the grass, thereby never allowing forest growth to regenerate from seedlings, and their sharp feet break the surface. Within historic times they have been the chief agents in the deforestation of the lands bordering on the eastern Mediterranean, whereby the hill-sides have been bared down to the rock, and the lower reaches of the rivers choked with silt and converted

into swamps. Greece affords notable examples of this destruction, but similar conditions are being set up in all parts of the world, nowhere more, perhaps, than in the southern United States. A few quotations will illustrate how serious the question is becoming in Africa.

Of South Africa the Native Economic Commission reports (paras. 72, 73):

'The worst effects of overstocking may be seen in some parts of the Ciskeian area, notably Middledrift, Herschel, and Glen Grey. In Middledrift there are large areas where the surface soil has been entirely eroded and no grass whatever grows. In the adjoining parts the grass is being speedily supplanted by *Helichrysum* and similar weeds. In Herschel and Glen Grey the vegetation of the mountain-sides has almost disappeared, the rainstorms send torrents down the slopes which wash away periodically large parts of very valuable and fertile soil. These two areas with fertile valleys containing great depth of soil show some of the worst *donga* erosion in the Union. The difference between these and other areas is one of degree only. In Geluks Location actual desert conditions have in twenty years been created where once good grazing existed.

'Unless precautionary measures are taken against overstocking the condition in the Transkei and the Native areas in the rest of the Union will be to-morrow what that of the Ciskei is to-day. The same causes are at work there, and they will inevitably produce the same effects in the near future—denudation, donga-erosion, deleterious plant succession, destruction of woods, drying up of springs, robbing the soil of its reproductive properties, in short the creation of desert conditions.'

The Basutoland Commission states:

'Erosion in Basutoland is no new phenomenon . . . but it is within the memory of the more senior Government Officers that it has assumed threatening proportions. . . . In the lowlands the main cause of soil erosion is the rapid run off from the lower slopes of the hills and kopjes, and from roads and paths, resulting in the donga. . . . It is probable that before the advent of the Basuto with his cattle, his sheep and his goats, a state of equilibrium had long been arrived at as far as run off was concerned. . . . The advent of man with his domestic animals, especially the goat, would transform this balanced state of affairs, gradually at first but at an ever-increasing rate. . . . It has been estimated that ten per cent. of the arable land is threatened

by existing dongas and in the lowlands, at any rate, it is the best land which is the most seriously affected.'

Giving evidence before the Kenya Land Commission, Mr. Hobley said (vol. iii, p. 3351):

'They have had a joint Committee sitting upon this question in Tanganyika Territory, where it is often severe. The native occupier, if space permits, moves on leaving exhausted soil and desert behind him. The damage is largely caused by the enormous numbers of goats. It is the same in South Africa. The animals' sharp feet make myriads of tracks up the ridges and the tropical rain scours the soil away. . . . The Teita country is even worse. There was a beautiful forest on the summit of the Dabida range, but now the ridges are all knife edges; you can hardly walk along them, and few trees remain. It is incredible the change that has taken place in the last thirty years. The last time I was up in Dabida in 1914 I was amazed at the state of affairs. The Dabida range is a fertile island surrounded by Taru Desert, which is absolutely arid country. They are rapidly destroying that area and it is desert all round and there is no water, and where they can go to cultivate I am unable to foresee. One of the greatest dangers in Africa to-day is soil erosion of the native reserves.'

Again, from the same report on other tribes, we read:

'When we turn to the reserves of the Suk, the Njemps, and the Samburu, the position is one of almost unrelieved gloom. The people appear to show absolutely no regard for the ruination which is going on before their eyes, but devote their lives to amassing vast herds of uneconomic live stock, which are fast turning the country into a desert' (Para. 1418).

'Major Grogan. With regard to the Kavirondo country I was very much struck by the obvious denudation and waste of land that is going on there. You can see it very well from the air. The land practically goes pink over large areas, and wise people leave it alone.'

Farther north Professor Stebbing in a recent paper[5] has described the encroachment of the Sahara through reckless shifting cultivation and overstocking:

'Some change in the methods of agriculture would appear imperative if a further migration to the south is not imposed upon it. Here the agricultural use of the forest is accompanied by the browsing and grazing of large herds of cattle and flocks of sheep and goats. Here again the numbers of animals are said to have greatly increased during the last two decades' (p. 509).

'Overstocking and tracking in the forest there is left, annual burning and sand invasion suggest the question "How long before the desert supervenes". But the end is obvious; total annihilation and the disappearance of man and beast from the overwhelmed locality' (p. 510).

Thus the problem of overstocking involves the preservation of the means of existence of many of the African tribes, because it is destroying the soil itself. It is a problem of the first magnitude, since it necessitates a change in tribal custom and in the whole mental outlook of the Bantu native.

As Mrs. Hoernle writes:[6]

'The cattle are a trust to the present generation from the past generation; they are a medium between the people who are here and those who are no longer here, as the Natives put it. . . . They are heirlooms; emblems of the status of the family. . . . When an animal is sacrificed, for example, they say "Father, here are your cattle; you have asked for cattle; here they are". That is why, when these cattle are used in marriage the ancestors must be appealed to to accept a transfer of the cattle to another kraal, because they are really the cattle of the ancestors. Therefore, always, in the original ceremony, an animal was sacrificed as part of the marriage ceremony, and through the groaning of the animal, or in some other way, the ancestors gave their assent to the marriage—accepted the woman into the kraal and allowed the cattle to go into another kraal.'

Everywhere a start has to be made with the culling of the stock. The Kenya Agricultural Commission[7] reached the conclusion that the first step must be the establishment of an abattoir and meat factory at a central point to which stock could be brought by road and rail. The first cullings would probably possess no value as meat; some of the flesh could be digested into meat extract, but most of the carcasses would have to be converted into manure. It is the wretched quality and condition of the majority of the animals that creates the necessity for a factory, for it provides a means of turning to some account the worst of the stock which have no value as meat. To the Kenya Agricultural Commission the native chiefs expressed the opinion that the older members of the tribe were conscious of the degeneration of their grazing grounds and would under-

stand the need for a compulsory reduction of stock. But they insisted that it must proceed by order of the Central Government; the chiefs' own authority would probably not be able to get the Native Council to carry such a matter. As one chief put it to me, action on his part except as carrying out the orders of Government would afford an opportunity for some of the younger men to make a bid for power by raising a popular outcry in favour of the old ways. Even in Africa the rising politician knows how to exploit popular and religious sentiment. However, it seems to be agreed that compulsion could be applied after a certain amount of education and would not meet with dangerous opposition. At the same time a serious educational campaign would need to be initiated in every reserve to teach the natives by example how to handle and select their stock for sale if not for their own consumption, and how to utilize the milk. This of itself is no light task, most of all in areas where overcrowding has already largely put an end to shifting cultivation. In some of the Kikuyu country the allocation of land amounts to no more than 15 acres per family, and this has to provide both for cultivation and the wandering stock. In some cases communal grazings are recognized and have become some of the worst examples of overstocking. Thereby too has sprung up another dangerous practice—that of squatter stock. Natives who have left the reserve to work on white settlements and are allowed to keep stock on such portions of the farm as have not been brought into cultivation, take in stock from their relations in the reserves, and the illicit movements of these stock to and fro contravene quarantine regulations and are a means of disseminating disease.

It is clear that the first step will have to be the establishment of meat factories at convenient localities, with provision of collecting centres and access. One such factory is already in operation in Tanganyika, and the Report of the Kenya Land Commission contains a full discussion of its costs and working expenses, for at first while the quality of the stock is so low and the chief output is fertilizer it is more than doubtful if it can be run to pay expenses. Regular

levies will have to be made by order on each owner's stock, no light question of organization and one that requires the co-operation of the chiefs. The stock will have to be paid for, and here comes in the main difficulty—the comparative indifference of the natives towards money and his traditional attachment to live stock, cattle in particular, as bound up with the lobolo custom and as evidence of dignity and standing within the tribe. To meet this psychological factor it was suggested in the Kenya Agricultural Commission Report (loc. cit., par. 129) that purchases of cattle might be met by the issue of a large coin or plaque of some bright bronze alloy, stamped with the image of a bull, numbered and registered against the man to whom it was issued. The tokens would be of the value of £2 and transfers would need to be registered, but they could be redeemed for their cash value on demand. They could be made so that they could be sewn on to a belt or cloak for purposes of display. Smaller tokens of the value of 10*s*. would be issued for sheep and goats.

This may sound a fantastic suggestion, but the situation it is designed to meet is fantastic. It is difficult for us to put ourselves alongside the minds of people who accumulate live stock to the acknowledged detriment of the land upon which they live, and yet do not use them for the very purpose for which man originally domesticated the animals, and this in spite of the fact that other neighbouring tribes do use the stock for both meat and milk. To us such an attitude may seem the height of unreason, but some of our own sacrifices to attain status among our fellows—honours and prestige—hardly bear examination in the cold light of reason. We have precedents for supposing that tokens, actual coins in fact, have attained a psychological value, something apart from their exchange rate as currency. Thurnwald[8] writes of the Mossi tribe in West Africa:

'The Maria Theresa thaler, now called a real, is worth 4000 cowries. Concerning the history of the Maria Theresa thaler, which worn as a pendant was actually regarded as possessing magical properties, we must refer to Fishel. In connexion with this, atten-

tion must be drawn to the fact that it was not the intrinsic value of the coin which led to its being so highly appreciated, but the effect produced by its general appearance on the African's primitive mind, which caused it to be regarded as a powerful talisman.'

It is difficult for any one who has not been through the country to realize how far the destruction has proceeded in some areas; one sees nothing but gaunt hill-sides, mottled with red, yellow, and purple where they are bared down to the deep subsoil or the rock, and sparse vegetation in the bottoms, gnawed and broken down by the starving animals wandering through it. The longer regeneration is put off the bigger and more difficult the task will become. In the early stages, natural vegetation will creep over the wasted area, provided it is shut up from grazing for a year or two. In the last stage the plants left are too few to supply seed and much of the surface has been cut down to an almost sterile subsoil; gullies and dongas render the land unusable. Deliberate reclamation is then necessary—terracing in the worst places to break the run of the rainwash, tree-planting to the same end, even the planting here and there of some of the stoloniferous grasses which are the best soil-binders in East Africa. In places some regeneration work has been begun, as in the Herschel district of Basutoland:

'The reclamation work is based more or less on the general principles described above, viz. by water control of the run-off from above and its distribution over the land. The task is a heavy one and will probably take seven years to complete, but progress has been remarkable in view of the difficulties encountered. We were also taken to see the work which has been completed during the two past years, and its effects, not only in the checking of further erosion, but in the rehabilitation of the affected areas where the vegetation was rapidly establishing itself.

'We were not surprised, therefore, on being told that, although considerable opposition was encountered at the outset from the people, the officer in charge had now more applications for works than he could deal with.

'In addition to money spent on purely anti-erosion work funds have been provided for the improvement of the amenities of the villages. Trees have been planted for future fuel requirements and fruit has also not been neglected. In addition, dams for watering

have been provided at convenient places; these fit in with the general anti-erosion scheme and are perhaps one of its most immediate attractions to the people' (p. 138).

'The total estimates are for 151,498 acres to be reclaimed and protected, at a rate of £1 per acre. This includes pay, staff and labour, also housing requirements, implements, minor essential fencing, etc. In fact all capital and recurring expenditure, details of which are to be found in Appendix 19 to this Report' (Native Economic Commission, p. 139).

It is thus impossible to exaggerate the gravity of the problems before the administrators of most of the native reserves in South, East, and Central Africa and as we have seen even in Nigeria. The population of both men and stock is increasing, the land is already insufficient to allow of the traditional shifting cultivation, and in many tribes land hunger is causing unrest. Meantime the overstocking is reducing and deteriorating the amount of land available for cultivation. The vicious circle is closing in at an accelerated rate. In places famine is at hand, but we British who have accepted a trusteeship for the natives cannot lightly allow it to do its ancient wrong of starving the population down to an equilibrium with the depleted resources of the land. For there is no need that the tribes should starve at anything like their present density of population. On paper the solution is easy; the administration has to secure the replacement of the shifting cultivation by a continuous regenerative system based upon a proper succession of crops, and a manure-making method like composting; the head of live stock, especially goats, has to be reduced drastically to numbers the natives can keep and utilize as food, regenerative measures have to be set on foot to reclaim the eroded land first into grazing, eventually to arable land. While the immediate obstacle is tribal custom and the native attitude to their stock, the crux lies in the paucity of the administrative staff the Governments can afford for service in the native reserves and the lack of resources for the necessary capital outlay on such matters as meat factories, demonstration farms, water supplies, and the reconditioning of the wasted areas.

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IV
THE NATIVE DIETARY

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It now remains to consider the actual food that is being consumed by primitive peoples like the African tribes, and how, with the reform in their farming processes, they can be ensured a dietary which is not only adequate in amount but which satisfies what latterly we have learnt to be the requirements of the human body for the food accessories like vitamins and minerals. We must not assume that experience and instinct will always establish a practice which provides for these requirements. One can find examples which show how natives have been reaching out empirically towards repairing deficiencies, as by the addition of certain leaves or mineral earths to the food, but in effectiveness they represent little more than the dog's habit of eating grass when it feels off colour. Individuals, indeed whole tribes, who have fallen below the normal in their dietary, affected also by the diseases which become widespread with under-nourishment, are apt to fall into a state of depressed acquiescence and lethargy until they do not even recognize their condition.

How low is the standard of living generally may be judged by an extract from the Report of the Kenya Land Commission,[1] which was dealing with by no means the worst of the African tribes, since, as we have seen, the population there is generally increasing:

'Dealing first with the great African population, the most striking facts which are to be noted are its poverty and its ignorance. Where the African is a wage-earner he is, as yet, but seldom able to earn more than a pound a month, and where he is a producer the results of his industry are, on account of his ignorance, still meagre to a degree. There has been improvement in regard to both matters during the present century, and in many places this improvement has been relatively great. It is probable that further and very remarkable improvement may take place in the future. Nevertheless, the fact remains that the population as a whole is still poor, illiterate, and uncultured. As a direct consequence, the conditions under which the African lives and under which children are reared are insanitary and

unhygienic in the extreme. It is hardly possible to over-emphasize the fact that the average native is born, lives, and dies amongst the most insanitary surroundings. His house is a mud-walled, grass-roofed hut, devoid of light and ventilation, and infested with vermin. Water supplies are almost everywhere either deficient or polluted, or both. The foodstuffs which are available in some districts are almost certainly deficient in quality, and though famine is not allowed to assume serious proportions, the actual amount of food available has a seasonable incidence varying between abundance and scarcity. Arrangements for the storage of food by individuals are primitive, and transport and distribution have not yet reached an advanced stage of development. The use of soap is not generally known. Cleanliness in the preparation of food has yet to be learnt. The necessity for cleanliness of the person is not generally appreciated; where it is appreciated, it is not always possible of achievement. The innocuous disposal of refuse and night soil is almost unknown. Beds, tables, chairs, and spoons are not in general use, and the household effects comprise little more than a few calabashes or earthen pots. The ignorance of the women with regard to the care of children is profound. In addition to ignorance, insanitary habits are imposed by superstition. Old-established customs are prejudicial to advance. Such are the people and their environment.'

In the Report of the Native Economic Commission[2] we get a description of the food of the South African tribes before the pressure of population had begun, which indicates not only an adequate but a reasonably balanced dietary, such as the examples of magnificent physique to be found among the Zulu, for example, bear witness to.

'In the matter of food the Native in his tribal state was accustomed to a very simple regimen. He grew a small quantity of grain by primitive methods of agriculture, enough for porridge and *mahewu* and beer. Pumpkins, beans, and a considerable number of lesser crops, found in different localities, gave variety to his diet. An important constituent was *imfino*, often, but not always, prepared from the succulent tops of various plants, e.g. pumpkin and pigweed, and served as a relish or condiment with his porridge. *Utywala* made from sprouted grain gave, in the opinion of present-day medical practitioners, a further vitamin content.'

Dr. Richards[3] again writes of the southern tribes:

'The southern Bantu are not described as typical agriculturists, yet in fact vegetable produce provides the bulk of their diet. Meat is a

rare luxury, and the daily food consists almost entirely of cereal foods and vegetables. A porridge of some kind is made by stirring the ground flour of one of the different cereal crops with boiling water, and this is eaten with a relish of vegetables—monkey nuts, beans, peas, etc. Among the Zulu-Xosa peoples, curdled milk forms an addition to the diet. The chief crops grown among these peoples—Kafir corn, Kafir pea, sorghum, maize, ground nut, manioc, sugar cane, and the different types of pumpkin—provide a rich variety of menu. In fact the diversity of plants cultivated among the southern Bantu is a characteristic feature of their agriculture.'

'Besides food also, the national beer is brewed from grain—a variety of intoxicating drinks prepared from mealies, millet, or sorghum. In our own community we do not have to choose between eating our staple food or turning it into beer. But in Bantu society, this is so; and such is the longing for excitement after the monotony of village routine that many tribes go short of food in order to drink.'

The cereal porridge, thick or thin, is universal throughout Africa.

'Instead of our regular three meals a day, the Bantu eats in general one large meal of cooked cereals, with meat or vegetable sauce, and two meals when he can. In the lean months of the year he may be reduced to forest fruits, caterpillars, mushrooms, and the like.'

One of the most careful examinations of native dietaries is to be found in the report of Sir John Orr and Dr. Gilks on the *Physique and Health of two African Tribes*.[4] These inquirers set out to compare the dietaries of the Masai, a pastoral tribe, and the Akikuyu, a typical Bantu people, predominantly vegetarian though they are also large owners of live stock. The report summarizes the food of the Akikuyu as follows:

'The Akikuyu are agriculturists and live on a diet which is chiefly vegetarian. Beef may be almost entirely discounted from the diet; game, fish, birds, and eggs are ignored and the eating of goats and sheep is almost confined to the old men. . . . Meat cannot be regarded as forming a regular part of the dietary. The amount eaten by women and children must be insignificant. It should be noted, however, that although so little meat is eaten the natives possess large herds of goats. These are used mainly as currency, instead of as a supply of milk and meat. The males show a preference for cereals and tubers, 60% of

their diet consists of maize and millet, and sweet potatoes account for a further 25%. The women . . . add more liberal quantities of legumes and plantains and have a virtual monopoly of the green leaves.'

It is explained that the women gather the leaves of certain plants, of which the native names only are given, and mix them with the porridge made from ground millet or maize, which is the staple food, and this especially during pregnancy. The analyses of Orr and Gilkes show that the leaves examined are especially rich in calcium, more so even than the leaves of British leguminous plants. The earth from certain salt-licks and the ashes of certain water plants are also eaten. Some of these contain considerable proportions of sodium and calcium. Orr and Gilkes sum up the dietary thus:

'The diet of the Kikuyu male is adequate in protein (though of a relatively low biological value) but very low in fat. It contains more than enough phosphorus, but is very low in calcium and possibly in sodium.'

The diet of the women is much the same except that their intake of calcium and sodium is much higher, of calcium about the optimum.

Of the results of this unbalanced ration the authors give several illustrations, of which the most cogent is perhaps:

'Of a labour strength of 14,400 employed on the construction of the Uasin Gishu Railway in 1923 the death-rate was 35·4 per 1,000 and the admissions to hospital during the year were 5,331. Improvement in the hygienic conditions and a change in the dietary in the direction of making it more varied and more like that consumed by Europeans, by decreasing the amount of maize and increasing the legumes, green vegetables, and meat, was followed by a fall in the death-rate. In 1924 it was 10·8 per 1,000.'

Orr and Gilks conclude by saying:

'The general improvement of agriculture and animal husbandry amongst the Akikuyu will almost certainly be followed by an improvement in the health and working capacity of the natives themselves.'

Turning now to the Masai, of old one of the most feared and ruthless warrior tribes of Central Africa, we have to deal with a Nilotic race and a more primitive culture, for

they are still a nomadic pastoral people moving with their herds and flocks over a wide stretch of country as the pasturage springs up in the different areas. It is estimated that the section of the tribe living in Kenya, for the tribe is divided by the boundary between Kenya and Tanganyika, possess about 25 cattle and 50 sheep and goats *per capita*. Very little cultivation is done by the Masai themselves, one consequence of their nomadic existence, but natives of other tribes do reside and cultivate within their borders and from them the Masai obtain a certain amount of vegetable food. Agriculture is, however, extending slowly; some of the chiefs cultivate on a fairly large scale. But from Orr and Gilks we learn:

'The staple articles of diet are meat, milk, and blood. . . . Various roots and barks are used to make infusions which are used either with boiled meat or with milk. The men, while in the "moran" or warrior class, subsist practically entirely on these articles of diet. The rest of the population, in addition to these four items, eat also some bananas, beans, millet, arrowroot, maize, sugar, and honey, as these are available.'

The detailed analysis of typical diets leads to the conclusion:

'The Masai diet contains a liberal supply of mineral elements and a large excess of protein and fat, but is low in carbohydrates. It must also be low in cellulose and other indigestible residues.'

The relatively fine physique of the Masai as compared with the Kikuyu is obvious: they are superior in stature and weight; when young they grow more rapidly. But their physical superiority cannot be wholly or even mainly set down to the diet; the Masai belong to an entirely different stock, Nilotic as opposed to Bantu, a stock everywhere characterized by the tallness of its men. Nor have we any trustworthy data to confirm the generally received opinion that the Masai possess greater capacity for work and endurance than the Kikuyu, for few of the Masai can be recruited for public works or the plantations. Later, however, we shall obtain evidence from the incidence of disease in the two tribes of the superior physical condition of the Masai.

It must be remembered, however, that this superiority of the meat-eating Masai is purchased at an immense cost in the matter of the land required. At the last census the population of the Masai in Kenya numbered 48,381, no very rapid increase from an estimated population of 40,000 in 1895. The Kenya Land Commission estimated their cattle at over a million, and an allowance of 74 cattle, 85 sheep and goats, and 18 donkeys per family of five. These are smaller numbers than those mentioned by Orr and Gilks, but they were regarded by the Commission as probably considerably below the facts. The Masai reserve in Kenya amounts to 14,797 square miles, so that the density of population is only about 3 per square mile. Nor must this low density be set down to inferior land, such as prevails in the northern territories and other arid grazing land in Africa, for much of the great plains over which the Masai roam are well suited to cultivation, though requiring water either from wells or dams to conserve the rainfall. The Wakamba live alongside the Masai in very similar territory, perhaps poorer now through erosion, and their average density is given as 48 per square mile; in the neighbouring Kavirondo the density rises to 145 per square mile and amongst the Kikuyu to 283 per square mile, these three tribes being agricultural and vegetarian.

There can be little doubt but that malnutrition is one if not the chief source of the incidence of disease among African natives, the extent of which is but little realized, for people are apt to think of the native as living in a state of rude health such as we associate with the animals in the same regions. African wild animals are, however, subject to many epizootics; indeed, Africa is the great repository of such diseases, both human and animal. 'Ex Africa semper aliquid novi' has been true since malaria was transmitted to the Mediterranean peoples and became one of the factors in the breakdown of the Roman Empire.

McCulloch[5] writes of the Hausas in northern Nigeria, Moslems with a comparatively advanced culture:

'A survey of a crowd in a market-place impresses the observer with the well-fed healthy appearance of the men and women. . . . From

just such a picture as this has arisen the popular and very ill-informed parrot cry of the "magnificent health" of the African savage. One week's experience of public health control, or hospital practice, will explode this myth for any intelligent observer. Experience knows that loss of nervous stability, high infantile death-rate, low reproductive capacity, and low resistance to infectious diseases are the rule in nearly all African communities.'

It would be going into detail foreign to my purpose to set out the evidence for the deplorable hygienic condition of most of the African tribes. The various Governments all maintain a public health service of which the reports are accessible; I would direct you to the report by McCulloch I have just quoted, or as an example of a detailed examination of one African tribe living in tropical conditions close to the Tana river, to the reports by Dr. A. R. Paterson of Kenya, for 1932 and 1933. In the heavily bushed country about the great lakes, Uganda, Tanganyika, the Belgian and French Congo, sleeping sickness renders uninhabitable great acres of fertile country; elsewhere there is nothing so signally devastating, but epidemics of cerebrospinal meningitis and relapsing fever have been widely destructive. The Annual Report of the Medical and Sanitary Dept. of Nigeria for 1924 states:

'In Kano and Kalsina, where records of deaths are maintained by the native administrations, the mortality is stated to have been appalling. . . . While Lagos had a death-rate of 23·8 per thousand, the death-rate in Kano was, largely because of these epidemics, 130 per thousand.'

Malaria, tuberculosis, venereal diseases, hookworm, and other helminth infections are universal, and apart from deaths bring about a general lowering of the physical and mental capacity of the race. What effect the deficiencies of diet have upon the intensity and incidence of these diseases cannot be exactly determined, but there is general agreement that the correlation is high. In French West Africa, where the population appears to be decreasing [in Dakar, for example, the death-rate is equal to or greater than the birth-rate] the Governor-General in a circular of 1924[6] declared

that the greatest obstacle to the increase of population was not disease nor the lack of hygiene, but the permanent food shortage which prevails. Again, in French Equatorial Africa a report of 1926 speaks of depopulation largely caused by under-nourishment:

'In general the native eats little and especially he eats badly. The composition of his habitual ration is defective, it is lacking in proteins and notably in fats. Inclined to laziness, thoughtless and improvident, the native becomes used to privation.'

In this region the density of population is only 2·2 per square mile, the lowest in Central Africa, and this is attributed by other observers to the combined action of disease and poverty due to the land concessions and heavy taxation. The Belgian Congo also shows a low density of 7 per square mile except in the mining zone of the Katanga, and here again the extensive concessions in the oil palm region, where the natives are almost reduced to the condition of labourers for the concessionaires, though they are the owners of the so-called wild palms within the concession area, are blamed for the bad dietary of the natives. The natives are more or less under pressure to grow crops for sale, and to feed the mining population attempts are made to produce food crops on European lines by concessionaires. Schwartz writes:[6]

'The principal cause of the depopulation of the Congo is the European penetration itself. The natives do not stand up under European civilization and all its corollaries: porterage, continuous labour, sudden changes in diet, more or less sudden transportation into another environment, in a word the recruiting of labourers from one territory for another.'

He goes on to express an opinion that the susceptibility of natives to sleeping sickness depends partly on whether or not they receive proper nourishment. These statements must not be held to apply generally to Africa; the increases of native population that have been specified in South Africa, Rhodesia, Kenya, and Uganda show that the African tribes have sufficient vitality to live in contact with civilization and still increase in numbers, provided that they are

reasonably free to enter into the white man's ambit at will or to remain within their own cultural group. The great problem of African administration is to hold the balance between the extremes of treating a native tribe as a fauna to be preserved in a sanctuary and, on the other hand, of regarding it as a source of labour for the white man's exploitation.

However, to return to the more immediate question of the observed effects of diet upon the incidence of disease, Orr and Gilks in the investigation I have previously quoted made a number of comparisons between the Kikuyu and the Masai, based in part upon individual examination of a sample population of each tribe and partly from records of hospital admissions. The sample may be regarded as small, but the differences are too great to be dismissed, confirmed as they are by general medical opinion of those in contact with the two tribes. I extract a few comparisons. From the examination of the children it appeared that 62·6 per cent. of the Kikuyu boys and 43·7 per cent. of the girls showed some bone deformity, while the corresponding percentages among the Masai were only 11·7 for the boys and 14·6 for the girls. Among the Kikuyu boys 40 per cent. showed some dental defect and 48 per cent. were clinically anaemic; amongst the Masai the corresponding percentages were 8·3 and 11·7 per cent. Again, the Kikuyu girls showed a lower incidence of all defects than the boys and were much superior in general condition. Generally speaking, the children in the Masai villages presented a very different picture, bone and dental defects being relatively uncommon.

The incidence of these defects is entirely consistent with the differences of diet recorded a little earlier. With the use of leaves in their diet the Kikuyu women obtain more vitamins than the men and an almost optimum amount of calcium, in which the man's diet is deficient. Of course, the Masai diet, both for men and women, is far richer in vitamins and minerals and in proteins of high quality derived from meat and milk. The hospital statistics, although again not as large a sample as could be wished, pointed in the same way to the effects of diet. Disease of all kind is less

common among the women than among the men in the Kikuyu reserve, notably so as regards tuberculosis. It should be borne in mind that the Kikuyu women do severe physical work, particularly in carrying water and firewood. Efforts have been made to discourage the heavy loads that the Kikuyu women carry because of their injurious effects upon childbearing, with little result, however, because the weight of the load they carry is a point of honour among the women. As regards the comparison between the two tribes, the incidence of malaria, yaws, helminthiasis, and ulcers is higher among the Kikuyu; on the other hand, the occurrence of chronic constipation and arthritis is higher among the Masai.

Following on the same line are the observations of Cleever[7] that dental caries, pellagra, and incipient pellagra are common among the Bantu of Zululand and the Transkei, whose diet consists largely of mealies, i.e. maize. Again, Gilks[8] points out that there is no dental caries among the inhabitants of Tristan da Cunha, who have no cereals but live on a diet which is mainly potatoes and milk. Gilks also attributes the prevalence of ocular trouble among the African tribes and of the scurvy in both South and East Africa to Vitamin A deficiency in the ordinary diets.

In 1931 the Medical Department of Kenya carried out a further survey of the health of the Masai, and in his report[9] Dr. A. R. Paterson summarizes the results of this and a similar inquiry into the health of the Wadigo, a coastal people living to the south of Mombasa. Dr. Paterson is less sanguine about the health of the Masai than were Orr and Gilks, though their state of nourishment was, on the whole, good; anaemia was only common among the babies, and there was little malaria or hookworm. But he goes on:

'We find a high incidence of tapeworm and roundworm, a very high incidence of pyorrhea, an incidence of eye affections suggestive of Egypt, and a child mortality rate bordering upon 500 per 1,000 births, while about 34 per cent. of the women appear to be sterile, gonorrhea being chiefly responsible.'

'A high rate of roundworm infestation is a sure index of insanitary circumstances. Tapeworm is to be expected among a meat-eating

people if cooking and sanitation are not understood. Conjunctivitis is also to be expected where water is as rare as manure is plentiful, and the uses of manure not understood.'

'Chronic dyspepsia as revealed by epigastric pain among over a quarter of the people is only a lesser evil, but hardly a sign of health. Green food and fruit are unknown in Masailand, and the women starve themselves in the last months of pregnancy in the hope of an easier delivery.'

Among the Wadigo the death-rate is estimated at about 21 per 1,000, pneumonia, dysentery, and malaria being the most destructive diseases, while the infant mortality rate is relatively low, between 100 and 150 deaths per 1,000 births. Anaemia is, however, much higher than among the Masai:

'The chief causes are probably ankylostomiasis, malaria, ascariasis, and an ill-balanced dietary . . . an ill-balanced dietary plays a large part not only as a direct cause of anaemia, but by reducing resistance to those parasites which cause diseases of which anaemia is usually a symptom. . . . Investigation as to the common dietary of these people reveals the fact that there is a grave deficiency in the iron intake. Muhagi (Cassava) or rice and fish, with very occasionally meat, and vegetables only when fish are scarce, and that may be only once a month, is a diet that is certainly badly balanced and lacking in a sufficiency of iron.'

Dr. Paterson concludes that the Masai, in spite of their better physique and meat and milk diet, are declining in numbers, but that the Akikuyu and the Wadigo are certainly increasing. The Akikuyu taken as a whole are fitter and healthier than the Wadigo; in both tribes the diet is defective and both suffer from a welter of diseases.

We may compare these conclusions with those obtained by McCulloch in his study of the dietary of the Hausas of Northern Nigeria. This people lives mainly upon the grain of two millets and sour milk, but still suffers from a low birth-rate and high infantile mortality, with a marked lack of resistance to infection. In 1925 an epidemic of relapsing fever in Northern Nigeria caused 128,750 deaths in the area in which McCulloch was working, no less than 5·15 per cent. of the total population. Tropical ulcer is common, and Orr and Gilks have already associated this

trouble with defects in the dietary, a conclusion confirmed by Dalrymple,[10] who was able almost to abolish this disease from natives in the Gold Coast mines by the use of a stew containing meat and the leaves of the sweet potato. McCulloch concludes that the evidence points to lack of vitamin A and specific deficiencies of iron, iodine, calcium, and sodium chloride in the diet of the Hausa. Generally speaking, it would appear that better dietary conditions prevail among the West African natives than among those of East and South Africa, because of the greater variety in the crops grown for food.

We may now return to the consideration of native farming to see how it can be rectified in order to provide a better balanced dietary, free from some of the deficiencies that have been reported.

The basic crop will continue to be cereals; no other crops yield so much maintenance material for the labour expended, and, as we have seen, cereal porridge forms the staple food of all Africans. The cereals available are the millets in large variety, *Sorghum vulgare* or Guinea Corn, and *Pennisetum typhoideum* or Bullrush Millet being the chief; maize, rice in certain localities, and wheat. Some of the millets are esteemed because they are easier to grind or pound, but from the dietetic point of view they are exceptionally deficient in minerals except phosphorus, and their proteins are of low biological value, being lacking for example in tryptophan.[5] It may be noted that little research and breeding investigations have been carried out with the millets; their potentialities should not be too lightly dismissed. Actually they are being steadily replaced by maize. Here again many varieties exist and it is unfortunate that in some countries there has been pressure to grow the white dent varieties for the export market instead of the round yellow maize of better cropping and feeding value. Maize shares the deficiencies of the millets, great shortage of minerals and vitamins, and a protein of low biological value. It is well known that excessive dependence upon maize leads to pellagra. Wheat can only be grown on the uplands, as in Basutoland and in Kenya, where its

growth is extending among the natives. One chief giving evidence before me in Kenya explained that the women were asking for wheat because they found that after a morning meal of wheat porridge the children did not cry for food before the afternoon meal, as they did after maize porridge. However, wheat is so localized that maize or millet must be accepted as the basic cereal and the deficiencies made up by the rest of the diet. *Eleusine* is widely grown though never in great quantity; information seems to be lacking as to the biological value of its protein. In Tanganyika it is chiefly used in making the native beer.

I have already insisted upon the importance of the legumes to the maintenance of the fertility of the land, but they are equally essential from a dietetic point of view, as they supply proteins of high biological value; they are rich in calcium and in certain cases in fat. The native African has a choice of a considerable variety of peas and beans, some indigenous, some introduced, but in Kenya, for example, neither natives nor white settlers seem to have arrived at the right bean for export and home consumption, which can be grown in rotation with maize. The earth nut (pea nut or monkey nut—*Arachis hypogea*) is very extensively grown in West Africa and is also generally distributed in all the warmer regions. While it is, unfortunately, almost wholly sold for export, its oil is used for cooking by the natives of Nigeria, and most tribes who grow it mix a little of it in their porridge. It is rich both in fat (up to 40 per cent.) and in protein of good biological value; its calcium content is not so high as with many beans. The growth has been extending among the eastern tribes, but more use might be made of it as a food supplementary to the cereals. It can even be made into a bread if the oil is reduced to about 5 per cent. by hot crushing. In the lowland areas the ground nut may well supply the food material complementary to millet or maize. But as regards a legume for Africa it is highly desirable that some breeding work on a large scale should be done with soya bean to evolve varieties suitable to the conditions of upland Africa. The soya bean is one of the most valuable food plants of the world, for its

seeds contain an exceptional proportion of oil of excellent food value, and again a protein content quite out of the ordinary. Moreover, the protein belongs to the casein group and possesses a high biological value. The soya bean is not of tropical origin and the varieties that have been tried do not crop well in Africa. But as yet the introductions have been made only on a limited scale and there has been no serious selection and breeding work such as has within a few years produced in America new varieties suited to their conditions, so that soya bean is becoming one of the staple crops of the Middle West and is extending into Canada. The plant has indeed proved so adaptable to varied conditions of climate and soil that breeding for African conditions ought to be taken up on a large scale with full power and not treated as a side issue in the already overcharged programmes of the agricultural experiment stations. A good bean that can either be consumed or sold is essential to both native and plantation farming in Africa, and it is not to be expected that a ready-made one is likely to be found. The climate of Central Africa is very much *sui generis*, so that introductions from other continents can rarely be acclimatized straightway; breeding must go on until varieties are found adapted to the conditions. Of course such a breeding programme should not be confined to the soya bean. There is always a presumption that an indigenous plant will respond better to development than any introduction. We have to bear in mind that the crops belonging to the older civilizations of Asia and Europe, and even of Central America, have been subject to many centuries of improvement by selection, empiric indeed, but none the less efficient because of the long period over which observation has extended. These plants are in consequence remarkably well adapted to their conditions, but with the indigenous food plants of Africa, a continent only just emerging from tribal migration and war, the processes of improvement are still in the very early stages. Here is indeed a great field for the scientific plant breeder. We should take example by modern Russia, which, having to provide a better standard of living for its great and varied popula-

tion, many of whom are not far removed from the primitive, has put the improvement of crops by the application of modern science into the forefront of its policy and has set up establishments of plant-breeding on an unprecedented scale. We want an African station, in the programme of which soya bean, the earth nut, the cowpea, and the velvet bean would have leading places.

Such a task is, however, for the future; meantime the necessity is mainfest for the inclusion, in the African sequence of crops, of a greater proportion of such leguminous crops as are available. Mr. L. R. Doughty has informed me that one of the obstacles to the greater production of beans is their bad keeping quality. The prevalence of weevil in the crops as harvested soon renders the store unfit for food; to minimize this loss the beans are generally hung from the roof of the hut.

Among other grains that are grown to a considerable extent is sesame or simsim (in West Africa benniseed), which in East Africa is used as a flavouring matter with the porridge, and by the Munshi people to a small extent as food. McCulloch has shown that the ash contains an exceptional amount of calcium.[11] With root crops the African native is already well provided; yams and sweet potatoes, cassava and latterly true potatoes in uplands, are regularly grown and form an accepted part of the dietary. There remains a final need for a greater proportion of green vegetables. All the observers I have quoted note the use of some green leaves in the dietary, as among the Kikuyu, where the women, especially during pregnancy, add certain leaves to their staple diet of a cereal porridge. In South Africa a sort of spinach is prepared; McCulloch reports of the Hausa as cooking thin leaves and mentions the sale of sweet potato leaves in the markets of the Gold Coast; Mr. H. C. Sampson has told me that in northern Nigeria and villages of the Gambia the Baobab (*Adansonia*) is regularly pollarded, the young shoots being gathered and cooked as spinach. In West Africa the Baobab is not truly wild but is planted round the villages. McCulloch found the shoots to be rich in calcium. But we do not find among the

native dietaries anything to correspond to the cabbages, kales, and other cruciferous plants which form the supplementary dietary both of the European peoples and in the Far East. I cannot attempt to specify the particular vegetables that should be grown; they must vary from tribe to tribe with custom and climate. It is a subject for trial and experimental work, especially of such cruciferous crops, brassicas and the like, as will adapt themselves to the local conditions, because of the general antiscorbutic value of that group of plants. The banana is grown in all districts where the rainfall is adequate; indeed, it forms the main food of some of the West African tribes. The coast tribes, again, make extensive use of the coco-nut.

Thus there should be no difficulty in establishing a sequence of crops that would provide the African natives with a duly balanced ration. In particular districts there may be specific deficiencies, of iodine and iron for example, that have to be artificially supplied. Steps, too, may be taken to improve the supply of salt as an article of trade. Calcium and phosphoric acid are generally present only in short measure in African soils, but the use of human excreta in the compost will help to maintain the circulation of these elements.

However, the most effective means of improving the dietary of many of the tribes would be to lead them to utilize more largely the milk obtainable from their cattle and goats. This is almost wholly a matter of education, and is the less difficult in that it does not conflict with the custom of lobolo. It should go hand in hand with the campaign for the reduction in the number of live stock and the better management of the remaining animals. In Kenya, among the Masai there is an educational farm on which young natives are trained in the care of cattle and the management of milk, which as the Masai handle it is always dirty and may be a means of spreading disease. Even at home one knows how easily milk becomes dangerous, and in Africa the temperatures are higher and water for cleaning processes generally scarce. Some simple training of the kind should be widespread, and indeed such demonstrations are already being extended in Kenya.

But even if the milk can be brought into the dietary it will be a far more difficult matter to bring about the consumption of meat, because of the part that lobolo plays in tribal custom. Natives may be induced to sell and utilize sheep and goats, the increase in numbers of which has only been due to the rise in the amount of lobolo demanded, but cattle stand on a different footing. As Dr. Richards[3] writes:

'The savage may want a certain type of food to satisfy the pangs of hunger and yet be reluctant to eat the object of so many complex emotional sensations. The resultant conflict usually finds solution in some form of sacralization of the particular food—some ritual act by which tradition prescribes that the food may be safely eaten.... In the case of the cattle-loving peoples of South Africa, this conflict is of course particularly acute, and a beast cannot be killed for meat without destroying what is, in effect, a personal friend.... The rites which surround the killing of cattle among most Bantu peoples, varying from refusal to kill cattle, to sacrificial slaughter on occasions like the birth, marriage, or death of an individual, and the ritual division of the animal killed.'

But even the strongest traditions of lobolo have to yield to circumstances. Mr. H. C. Sampson has told me, for example, that the tribes along the Tana River, originally a cattle-owning people who have migrated to a region where cattle cannot be kept because of the seasonal flooding, have substituted beehives for cattle in their lobolo. The young man seeking a bride must make and erect in the trees the agreed number of beehives. But in general there need be no interference with cattle beyond the necessary reduction in numbers; under proper management for milk production they can become most valuable elements in a good agriculture and a sound dietary. The brunt of the campaign against overstocking should fall on the goats, which are less than ever valuable to the natives because they are everywhere tending to abandon skins for clothing in favour of imported fabrics. One other live-stock item is being encouraged by the agricultural departments—the keeping of poultry, the native stocks of which are easily improved by the introduction of European breeds. Eggs would form a valuable addition to the native dietary, but the danger is that they will be

produced only for sale. We see, for instance, how reluctant our own small-holders are ever to eat the eggs they raise.

There are other factors in the improvement of native agriculture which lie outside my immediate purpose, such as the introduction of labour-saving implements. Native cultivation was wholly done with a kind of hoe, and much more effective tools than those of native construction are now becoming general. A far greater saving of labour, however, comes with the introduction of the plough, and this is now being adopted by individuals in many of the tribes, especially where the natives are embarking upon crops for sale. One other important result which follows is that since the plough requires cattle to draw it, its use is helping to break down the cattle complex and to establish for them an economic rather than a religious status.

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V
ADMINISTRATION

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ADMINISTRATION

In the preceding lectures I have endeavoured to put before you the dangerous condition into which the East African tribes in particular have arrived—the increasing population both of men and animals that has followed the cessation of war and raiding, the steady diminution in the productivity of the soil as it becomes no longer sufficient for the traditional practice of shifting cultivation, the overstocking of the grazing grounds, the continued extension of soil erosion. The imminent consequences are disease due to inadequate food, tribal unrest, and the spread of the desert. It is difficult to exaggerate the gravity of the situation: but what is to be done? There appear to be three policies for dealing with native affairs, each of which has its advocates and each of which is more or less illustrated in Africa. The first might be called the museum or nature reserve method, the policy of isolating the tribe and of using all endeavours to preserve with almost religious respect its tribal conditions and customs, with the expectation that the natives will thus develop their culture in their own way without the risk of falling into a bastard culture embracing the evils of both European and African life. While we may agree that much harm has been done to native communities by self-complacent assumptions that the native is a child who only needs to be brought up on good English principles in order to take his place in our civilization, I cannot admit that the cultures of the African tribal kind are good *per se*, or represent much more than early experiments in social organization which for one reason or another have remained comparatively sterile. I feel that the desire on our part to preserve these communities unspotted from the world proceeds less from sympathy and understanding than from a presumption of superiority that would like to maintain samples of the varied world for the satisfaction of our own curiosity. Others, again, hold the opinion that the white man is an unwarranted intruder in Africa, who is stealing

land from its original owners, and that though the first wrong done cannot be repaired it is incumbent upon us, now that consciences are awakened, to restore and safeguard the old tribal organization as far as possible. But if natural justice demands the limitation, almost the expulsion, of the white settlers, it must not be forgotten that the black tribes of to-day were intruders at some earlier period. Indeed the Akikuyu only arrived in their present location about a hundred years ago. If then the land ought to be restored to its original occupiers it should be left to the wild fauna, as indeed some good people would prefer. But whether we like it or not, the preservation of tribal culture in its purity has become impracticable. Contacts with European life have been established, and the natives in general, not merely a picked few, themselves desire to enter into the general stream of European culture, and will contest any attempt to confine them within a black civilization which, however developed, would always connote inferiority. Even the Masai, a race of primitive pastoralists, who in Kenya regard themselves as sovereign in their own territory, secured to them by treaty with the British as of one nation with another, are yet visibly changing under the proximity of the railway, the road, and the white settlements. Nor can Africa afford many reserves like the Masai, good agricultural land for the most part with a population averaging three per square mile. Moreover, the purely non-interference policy, according to the evidence I have put before you, is rapidly resulting in famine and the growth of desert; non-interference as our only policy would allow famine to do its work and war to be resumed until the population is checked down to the means of sustenance. Even the more limited policy of non-interference known as 'indirect rule' through the chiefs, which prevails in some of the African governments, though it leaves local administration and justice in native hands according to custom, and only exercises a certain overlordship and supervision, yet must gradually modify the natives' way of life. It is inevitable that the European, having arrived in Africa and having exercised that major interference of putting an end to war, of old the

condition on which the whole tribal policy was based, must go on with the work and become responsible for the organization of a new society.

It follows that as alternatives to pure non-interference, to forming reserves like that of the Masai, the Governments can either treat the natives as material subservient to their own purposes of exploiting the resources of the country, as a reservoir of labour for the mines or the plantations, or they can accept a trusteeship to develop the country for its native inhabitants. One may cite Uganda or Nigeria as examples of the application of the latter principle; it is, perhaps, not unfair to regard the Belgian Congo as typical of the other method. Indeed as far as the British colonies in Africa are concerned, the conception of trusteeship has been officially declared in the White Paper[1] of 1923, and this trusteeship does involve the responsibility of leading the tribes out of the *impasse* into which they are drifting when left to manage their land according to their old methods.

I have endeavoured to indicate the essentials of a new system: (1) the replacement of shifting cultivation by a fixed agriculture which will maintain continuous production from a smaller area, leading to a more balanced dietary; (2) the elimination of excessive live stock and the utilization of the remainder to provide food; (3) the prevention of soil erosion and the reconditioning of the devastated areas. It remains to consider the machinery by which these great tasks can be accomplished. The problem is essentially one of education, for even where administrative action is called for, as in the culling of uneconomic stock, it must be preceded by a campaign of enlightenment that will render it acceptable and in consequence effective. It has been questioned whether the African native can be so educated, whether his mental development is not arrested at an early stage so that he is incapable of assimilating a more rational rule of life. On this point those who have been most closely concerned with the education and training of the African peoples speak in definite terms. There is no congenital bar to their mental development,

though data are lacking from which to estimate the general level of culture to which any race can attain. The backward position of the African natives in general is largely a matter of environment; war, poverty, and disease have acted and interacted to restrict the growth of their intelligence. Not only are individuals to be found who have pulled out of their conditions and shown that they can live on competitive terms among Europeans, but it must be remembered that in any society the individuals who live by reason and of their own volition embrace the scheme of life of their community constitute a rare minority within it. The mass of the people live by routine and act in accordance with the framework of the society within which they find themselves. It is precisely in this matter of tribal custom that the difficulty of education resides. *Per se* it is no more difficult for an African family to cultivate a piece of land on the lines indicated for permanent agriculture, than to follow its ancient custom of shifting agriculture, but that method is at present bound up with his tribal organization and his religion, the whole social framework which gives him status and a place in the community. That he can adopt, and thrive in, a new environment is abundantly seen when he goes to work in the mines or plantations, crude as have been the means taken to assimilate him to his new conditions; still more has he to change when he joins a native regiment, where he does receive a certain amount of social and hygienic discipline.

I do not propose to deal with the general question of education; reading and writing do not matter until the material basis of living has been assured. Even in our own society we see the instability and misfits brought about by a system of education that was solely concerned with the brain to the neglect of the hand and eye. From my point of view the need of the African is training upon the land and in the workshop rather than in the school.

For the improvement of native agriculture the machinery consists in the main of the agricultural staff maintained by each Government and of the administrative officers living in the reserves. I do not want to belittle the value of the

introduction to better agricultural methods that is given in the mission schools and organizations like the Jeanes' School at Kabete, in Kenya.[2] Directly they may touch but a minute fraction of the population, but they will provide the material from which may be drawn the instructors on whom will have to depend the routine supervision of the bulk of the natives embarking upon new methods.

The agricultural staffs working in the African Colonies have been greatly expanded during the last twenty years and were still growing until the call for economy in 1931 restricted development. But it will be found that their attention has been almost wholly concentrated on the plantation industries and the crops that can be grown for sale. That has been almost inevitably the case because it is through these exports that revenue is earned and the service can be paid for. The white settlers and the merchants who handle the export crops, in West Africa for example, are the people who call for investigation of the problems arising in the growth of the products they are concerned with, and not unnaturally they determine the programme of the agricultural departments. Moreover, the opinion is often expressed that the readiest way to teach the natives an improved agriculture is to introduce them to the growing of a crop for sale in their own reserves, by working on the white plantations. The scientific officers in the African colonies have been trained in European experiment stations and laboratories and bring to Africa a preoccupation with the class of problems they have worked upon at home, so that they tend only incidentally to come into contact with native agriculture for subsistence. It is not unfair to say that this side of agriculture has received but little attention from either the administrative or the agricultural officers. Of 42 technical agricultural officers in the Kenya service in 1929 only 12 were employed on native reserves. I can recall a good deal of work on African soils, but it has been almost wholly pure pedology or the application of pedological methods to determine whether this or that type of soil would carry plantation crops like coffee or tobacco, and only to a slight extent has it dealt with the basic questions for

native agriculture, such as the restoration of humus and the maintenance of fertility. Research has enabled wheat to be grown for export in Kenya, but I am not conscious of any systematic work on the native millets. Of the need for a full-power breeding programme to create better legumes for Africa I have already spoken. And if I sometimes feel impatient when I read from an African source a contribution to one of those fundamental but unessential problems on which the laboratories of two continents continue to exchange inconclusive papers, I have to recognize that this may be the only way the writer manages to preserve his faith in science in an alien world. To few men is given the courage to seek out for himself some corner of that dark and ungrateful continent to reduce to order.

However, I have no wish to question the valuable work that is being done by the men of science at work in Africa; they are all struggling with a bewildering excess of questions to which there is no ready-made answer; I am only asking for a considerable increase in their numbers in order to deal with this fundamental question of the preservation of African soil.

There is some investigation to be done on the most economic adaptation of the composting method to the native agriculture and materials in each district. One would like to see some inquiry into the nutritive value of the native food crops, and there is the necessity of a sustained programme of breeding. But it is less research that is needed than the organization of a chain of instructors and demonstrators. Probably the bulk of the work can be done by native instructors, who have already proved very valuable in many of the dependencies, and the method likely to prove most effective is that adopted by Mr. Lambert of getting the occupier of one shamba in each village to cultivate it on the improved lines. The method has to be thought out in detail and operated on the land of the native schools so that the future instructors are drilled in all the operations; the European instructors will be chiefly occupied in this initial training together with the constant inspection in the reserves of the work of the native instructors.

To bring about the improvement of the dietary and the extended use of milk possibly female native instructors would be most effective. But the main propaganda towards improvement must rest with the administrative staff, for the District Officers constitute the prime source of authority, they deal with the chiefs and exercise an almost parental influence in the reserves. The Kenya Agricultural Commission recommended that

'the Agricultural Officer should be seconded for service in Native Reserves and should be attached as adviser to the Provincial Commissioner. . . . Native instructors must receive direction as to the methods and object of their teaching from the agricultural officers, they should be placed under the immediate local supervision of the District Commissioner.'[3]

The District Officers must be possessed of the whole policy of betterment, and what one would like to see is in the first instance a general plan prepared for the colony or dependency, followed by special plans for each reserve based upon the local considerations advanced by the District Officers. It is a big programme that is called for, and though fortunately it can be put into operation piecemeal, each element requires to be treated as part of a general plan on which the administration is continually working. The straightforward improvement of the native farm, by the introduction of composting and better crops, will have the effect of relieving the pressure on the land and ameliorating the native dietary; and the disposal of human excreta in the compost will have no little effect upon public health. The live-stock question, as we have seen, is a larger and more difficult one, because it is so intrinsically bound up with tribal custom and religion. Compulsory measures are required, and the Central Government will have to exercise all the influence it can upon the Native Councils and the Chiefs to render the culling acceptable. Widespread propaganda is needed to bring about the general use of milk as food among the tribes who are still almost wholly vegetarian, and of cattle as draught animals in the reserves where ploughs can replace the hoe. With it will go instruction in the selection and management of live stock that

remain, a process that in most cases will involve fencing. Fortunately, most of the colonies possess a relatively large veterinary staff, who, if they have hitherto been chiefly occupied in the reduction of the incidence of disease, are equally fitted to control a campaign of betterment, one of the greatest obstacles to which is the vastness of the herds and flocks accumulated without regard to quality. The prevention of soil erosion and the regeneration of the wasted areas are the final elements in the programme. Communal grazings have to be taken in hand, many of them require to be ploughed up and resown by degrees. The larger areas can only be shut up and left to accumulate a natural vegetation again, though a certain amount of engineering work is required to reduce the violence of the run off. Such works, like the construction of wells and dams, are tasks for the Native Councils to carry out with their power of calling upon tribal labour.

The whole programme is, inevitably, both costly and slow, since it has to bring about a change in the mentality and the deep-seated tribal customs of the native population. It calls for a great extension of the staff employed in the reserves of European administrative and agricultural officers and of native instructors. It requires additional research. Considerable capital expenditure is needed to establish the meat factories, and to finance the regeneration of the wasted areas and to improve water supplies.

Such expenditure is certainly beyond the immediate resources of the colonies themselves; it cannot be carried out except by financial aid from home. The policy of the British Government has always been based upon the idea that each colony must pay its way. Loans may be made for railways and similar works, necessary for strategic purposes and for the trade of the white settlers and concessionaires, and while in principle the colony is regarded as responsible for the service of the loan, it is tacitly admitted that payment can be deferred and may never accrue. But the home government has never contemplated any wholesale plan such as I have sketched for the amelioration of the conditions of the natives themselves. It has been taken for

granted that the contacts with the settlers and the plantations will provide the necessary education and insensibly ameliorate native practice. And yet, as I have endeavoured to show, it is precisely those contacts that are destroying tribal custom and discipline; it is our occupation that has led to the growth of population, the overstocking, and finally to the destruction of the very land itself. It is becoming a matter of life and death to the natives and we cannot shirk our responsibility. Large as is the expenditure called for, it would be practicable enough if we had any money to spare even for our problems of betterment at home. We have abandoned the idea that Africa can on any large scale be 'settled' or can provide for the overflow of our European population; that we now see is physically impracticable. There is room for some white settlement and for white occupation, but in the main the burden is upon us of making Africa fit for the Africans. If we fail, the white occupation fails also. Africa can never be dealt with like North America or Australia. But what can there be to repay Great Britain for the expenditure that is needed, must it be all pure philanthropy? By no means, there is trade to be earned. Every improvement in the standard of living of the African, every increase of population that can be lifted above the bare animal level of subsistence means a demand on our industries for commodities of all kinds, from cotton piece goods to motor-cars and steel girders. Our exports to Africa are at present small enough, and those on the spot deplore the extent to which the native is being supplied from India, Japan, and America. It has been suggested that our manufacturers are not sufficiently aware of the nature of the requirements and that an expert inquiry into the exact nature of the articles the African wants to buy would be repaid. Such trade becomes more and more essential to our home industries as foreign countries raise their tariff walls even higher. We have got to think of Africa as part of the great British estate that is still but partially developed, and of the Masai and the Kikuyu as potential economic citizens of the Empire.

But when I speak of Africa as part of the British estate

to be developed I am reminded of the existence of unbalanced dietaries and unco-ordinated agriculture in Great Britain itself. The evidence is steadily accumulating that no small part of the burden of disease that our own people carry is due to malnutrition, not so much actual shortage in the amount of food consumed, in the calories necessary to maintain life, as a clinical condition due to ill-balanced dietaries and the insufficient provision of vitamins and minerals. This tells most heavily on the child, even in its earliest stage in the pregnant mother; the seeds of weakness are sown then and a condition is set up of susceptibility to functional disorders which persists through life. Even in the food of the adult, when vitamins are of less account than in the growing child, these deficiencies are common; overeating, indigestion, and dyspepsia are not uncommonly the consequence of an instinctive endeavour to secure enough of the food accessories from a diet that does not contain a proper proportion of them. 'Drink more milk', 'eat more fruit' are more than mere slogans for the benefit of the producers and vendors of these commodities, they are highly necessary advice for the general health of the community. It is hardly my place to set out the evidence for the prevalence of malnutrition in our people. Some of it may be lacking in precision and experimental verification, but the members of the medical profession and the research workers who are concerned with children are in no doubt of its gravity. We have now an accumulation of evidence that malnutrition is present among the children attending the elementary schools, that their health and growth rate is below that of children attending the middle-class schools, and that in both classes of school it can be improved by improvements in the dietary, particularly by an increased consumption of fresh milk.[4]

Other observers have shown the prevalence of anaemia in expectant mothers and babies[5] due to iron deficiency, while evidence of shortages of vitamin A leading to eye and skin trouble,[6] of vitamin C leading to scurvy in extreme cases,[6] and of vitamin D leading to rickets and dental caries, is accumulating every year.[7]

I may instance the fact that emerged of the increase of malnutrition among the children of those sections of our working population who have moved out of the slums into the new housing estates round our cities.[8] The family income has been restricted by higher rents and the cost of daily transport to work, the necessary economies have been made up on food and the children suffer. It is not merely that there is a reduced expenditure upon food, but the materials are dearer because the people have lost their access to the cheap markets which were near their old quarters. Let us not for a moment suppose that the price of food is not a dominant factor in the character of the dietary; every diminution in income tends to divert it in the direction of bread and cereals as the cheapest sources of energy, tends to reduce the intake of food accessories. I recall talking many years ago to a very intelligent farmer not far from the Midland 'Black Country'. He told me that in making up his programme of cropping he watched the wage level in Wolverhampton. If it was good, he planted more vegetables—savoys, Brussels sprouts, and carrots; if trade was bad, he substituted potatoes. The housewife must have potatoes, but economized, he found, on green vegetables if her cash was limited. Spence and Charles in Newcastle, in February 1934, found that a rise in the price of milk to 7*d.* a quart sufficed to increase the percentage of families who bought only condensed milk from 27 to 35. Not only is there conclusive evidence that the lower the family income becomes the higher is the proportion that bread and other cereals have to occupy in the dietary, but we have to bear in mind that with restricted incomes fuel also becomes a consideration and creates the urge towards tinned and other prepared foods, all of which tend to be deficient in vitamins and other food accessories. It is true that the margarine manufacturers now add vitamin A to make up the deficiency in the fats they use as compared with butter, and that only vitamin C is rapidly destroyed by cooking. None the less we must recognize that nearly every method of preparing and pre-cooking food removes some of its natural food accessories. Yet tinned foods are assuming

year by year an increasing place in the national dietary, not necessarily in the poorest classes but, perhaps, even more in middle-class households where the daughters are becoming accustomed to going out to work, and where the art of cookery is little appreciated as against the time and care that it demands. It is on the growing child and on the expectant mother that these defects of diet weigh most heavily; it is the coming generation that will have to pay. No task is perhaps more difficult than to bring about a change in the domestic habits of a people, other than those that are insensibly adopted in response to economic pressure and those major alterations in the environment such as are caused by the growing aggregation into large centres of population.

What, then, is needed in the first instance is a national campaign of enlightenment on the essentials of a healthy dietary. It must begin in the schools, where some instruction in the broad principles of hygiene should become part of the equipment of every boy and girl. It should be addressed to adults through the general press; accustomed as we are to the organization of propaganda on behalf of this or that political or commercial interest, it should not be impossible to utilize the now well-established technique in a national interest. There should be a more direct propaganda addressed to all bodies who are responsible for the feeding of children, to schools and institutions, even to hospitals. For if I may trespass on the ground which belongs to another profession, there is need to make many members of the medical profession nutrition-conscious. I am told that instruction in that subject, especially in its recent developments, occupies but a perfunctory place in the medical students' overweighted curriculum. There is doubtless opportunity for more investigation, what is the normal intake of food accessories on the current dietaries for different classes and ages of the community? The desirable amounts and the minima for safety have already been established. It is so easy even for those who are aware of food deficiencies to maintain that the ordinary mixed diet supplies all that is required, and yet on exact examination the statement proves illusory.

But whatever our propaganda it will be unavailing unless the commodities that will supply the food accessories are generally accessible and the desiderated dietary is within the means of all classes of the community. And here comes the problem, entirely analogous to that with which I have been dealing for Africa, of adjusting the national agriculture to supply that which its people require. Broadly the essentials are an increased consumption of milk and milk products, of meat and eggs, of fish, of green vegetables, and of fruit, and a less dependence on the foods that are mainly, if not wholly, suppliers of energy, like bread and other cereal foods, and sugar. The prime objection lies in the fact that the desiderata are generally more costly, for the simple reason that they require either more labour or more raw materials for their production, when compared on the basis of equal value for sustenance. All animal foods—meat or milk or eggs—are secondary products, made from the prime output of the soil. Hens eat grain to yield eggs, the cow's milk represents a definite consumption of grain, roots, and grass. And the conversion, from the point of view of energy supply, i.e. of material to keep the human machine at work, is a wasteful one, even when every allowance is made for the fact that the animals can utilize coarse fodders like grass and a variety of residues from the preparation for human use of other soil products. It has been estimated that to produce food containing 1,400,000 calories, i.e. a labouring man's allowance for 400–500 days, 0·76 of an acre would be required when cropped with potatoes, a little more, 0·79, when cropped with maize, or 1·45 acres of wheat to be turned into flour. But to supply the same number of calories in milk 2·35 acres of cultivated land and 1·6 of pasture are employed, as pork 3·7 acres of cultivated land with 0·7 of pasture, as beef 11·3 acres of cultivated ground and 2·5 acres of pasture.[9]

In the same way we must recognize that most green vegetables and fruit are relatively greater consumers of human labour than the cereals; to keep a man alive on potatoes will consume more labour than to support him on wheat. We may to a certain extent discount these

differences of prime cost on the score that the price of raw material is generally but a small element in the price the consumer pays; the wheat in a 6*d.* loaf of bread costs, perhaps, 2½*d.*, and with other commodities the disproportion is greater. But the foods of which we desire an increased consumption are precisely those in which the costs of preparation for market and distribution accumulate; milk, meat, fish, green vegetables, and many fruits are perishable and bulky; wheat, rice, sugar are among the most easily handled commodities. Let us, however, consider another aspect; these dietary desiderata are the very commodities which our climate and soil are best fitted to produce. As regards meat and milk, our adequate and evenly distributed rainfall, our equable temperatures, are favourable to the growth of grass, and recent science has taught us how to enlarge the production and enrich the composition of grass, thereby to cheapen the output of milk and meat. Equally our climate and certain of our soils are suitable for a great expansion of the production of vegetables and fruit, and singular progress has been made in the skill and knowledge required for the cultivation of these commodities. Indeed the growers tend to complain of glutted markets and over-production.

One further consideration is germane; the agricultural commodities we thus need to increase the national dietary demand a comparatively high degree of technical skill; they respond to the applications of science and organization, they are not the crude output from the soil that will follow from a minimum expenditure of man-power on the wide areas of the new countries or from the cheap labour of over-populated agricultural communities in the tropics and elsewhere. Why should we strive to extend the cultivation of wheat beyond the limits of those areas in England where it can be cheaply and appropriately grown? No crop can be more roughly and inexpensively produced, no crop can be more easily transported; it is the raw material for more intensive industries like pig and egg production. The fact that should dominate our agricultural policy is that of necessity we must purchase the greater part of our food,

and therefore a selection in the articles to be produced at home is forced upon us. If we take the crude measure of values we import about 60 per cent. of our agricultural requirements, and while I agree that this percentage can be materially reduced to the advantage and not the detriment of the general trade economy, there must remain an ample margin within which to plan the trend of our domestic production.

Now we are committed to the policy of a planned agriculture; we are possessed of the legislation necessary to control any and all of our agricultural industries; many of these Marketing Boards, that have been given a monopoly of sale of the commodity or are able to move for fiscal regulations to limit overseas competition, are already at work. What I am pleading for is that these powers should be exercised in conformity with a national plan, designed to provide the bulk of our people with an improved dietary that will ensure a better standard of health throughout our race. In the present state of financial confusion among nations it is necessary to continue financial assistance to agriculture in this country, and in one form or another some £17,000,000 per annum[10] is being contributed out of the general purse for such purposes. That burden will be more willingly borne if it is recognized that it is not a mere subsidy to enable farmers to continue as they were or to maintain commitments entered into without consideration of the wider issues involved, but is being directed towards an agriculture that agrees with the conditions of our soils and climate and that best subserves the needs of our people.

But let me return to my proper subject—native agriculture. I have endeavoured to show that native agriculture, especially in those vast regions of Africa for which we are responsible, is inadequate to provide for the growing population, that it is leading to land hunger and political unrest, that it is wasting and will eventually destroy even the present limited production from the land. I have indicated a method of scientific validity by which the shifting agriculture can be replaced by a fixed agriculture, capable of

maintaining indefinitely the producing power of a given piece of cultivated land. This system will repair deficiencies in the current dietary, will raise the standard of living among the natives, will improve their physical condition, and will help to ward off some of the diseases to which they are prone. Is this enough? are we not offering a temporary palliative? will not the population again grow up to and beyond the means of subsistence, even at the new level of production from the soil? In the first place, the system I have suggested is necessary to save the existing population, it is not merely a means of increasing production from the soil but a method of conserving the very soil itself. None the less, it may be expected to increase the amount of food available among the natives and to raise their standard of living, and that, as experience seems to show, will be accompanied by an automatic reduction in the rate of increase of the population.

'Throughout our investigation, we have constantly been impressed with the thought that mere material improvement alone will not bring lasting benefit to the agricultural population. . . . No lasting improvement in the standard of living of the great mass of the population can possibly be attained if every enhancement in the purchasing power of the cultivator is to be followed by a proportional increase in the population.'[11]

But I agree that our responsibilities to these native populations do not end with the amelioration of their food supply. We have interfered with their own culture, we have taken away one outlet of their activities—war, we are proposing in the interests of their food supply to cut deeply into their tribal customs and religion. We have to take thought of these imponderables. In place of war we might be able to give them sport, for it is no idle fancy to suppose that the innate combative instincts of man can find their emotional relief in football and the like, and that war need no longer be a necessary katharsis for the human race. It is not unreasonable to suppose that if we can relieve the grinding poverty of the natives we shall have taken the first essential step to liberating their emotional and spiritual life also.

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PRINTED IN GREAT BRITAIN AT THE UNIVERSITY PRESS, OXFORD
BY JOHN JOHNSON, PRINTER TO THE UNIVERSITY


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