WORLD RESOURCES AND TECHNOLOGY*

L. Dudley Stamp†

I

The Basic World Problem

The fundamental problem that faces the world today is the rapidly increasing pressure of population on physical resources, particularly on resources of land.

In contrast to the position at the end of the eighteenth century, when Thomas Robert Malthus published the first edition of *An Essay on the Principle of Population as it affects the Future Improvement of Society,* there are no new lands to be discovered. At that time, the existence of Antarctica was unknown, neither Australia nor New Zealand had even been roughly charted, the whole heart of Africa was unexplored by Europeans, and the great fertile plains of the American West lay an unbroken stretch of grassland. Today, exploration has come to mean the more detailed study of what is already known to exist. The area of the earth's land surface is fixed and, broadly speaking, inextensible. Although the reclamation of the former Zuyder Zee and the alluvial banks at the mouth of the Rhine represent a gigantic national effort of the Dutch, in terms of the world's land area, such additions are infinitesimal. The world's land area has been calculated at 57,168,000 square miles—36,586,000,000 acres or 14,812,000,000 hectares. This includes 4,410,000 square miles for Antarctica; and even if it is proved that the "land" is in two parts separated by an ice-filled oceanic trench, at the temperatures prevailing, permanent ice is a rock and may be regarded as constituting part of the earth's land surface.

Against the background of a fixed, inextensible land area is the phenomenon of the human race expanded at a rate never before reached in world history. The knowledge and practice of death control have spread much more rapidly than the knowledge and practice of birth control. Within the last fifty years, the old "killers" such as malaria, yellow fever, cholera, plague, typhoid, smallpox, and diphtheria, even tuberculosis and venereal diseases, have so far been brought under control that the knowledge and skill exist to eliminate them. Maternal mortality has become

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† B.Sc. 1917, M.Sc. 1918, D.Sc. 1921, B.A. 1921, King's College, London; D. Lit. 1949, London School of Economics and Political Science; LL.D. 1955, Clark University; Ekon. D. 1959, University of Stockholm; Commander, Order of the British Empire, 1946. Director, World Land-Use Survey; United Kingdom Delegate on Land Use, Food and Agriculture Organization, United Nations; Professor of Social Geography, Emeritus, University of London. Formerly Director, Land Utilisation Survey of Britain, 1930-48; Chief Adviser on Rural Land Use, British Government, 1942-55. Author, Asia (1929); Africa: A Study of Tropical Development (1953); Land for Tomorrow (1952); Our Developing World (1960); Applied Geography (1960).

almost a thing of the past in the more advanced countries, and infantile mortality has been reduced to a third or a quarter of old figures. Expectation of life has been doubled; at the other end of the scale, in countries such as Britain and France, one person in eight is now in the old-age pension class—over sixty-five. As sanitary conditions are improved and health services expanded in the less-developed countries, the net rate of population increase is bound to rise, unless there is an unexpectedly sudden swing towards universal family planning.

The present position may be summarized by referring first to total world population. The last of the great "unknowns" was eliminated when China carried out its modern-style census of 1953; not more than half a dozen significant countries have now no modern census, and every year figures collected by United Nations assume a greater accuracy as regards both total population and rate of increase. On January 1, 1960, the total of 2,900,000,000 is almost certainly within five per cent of the truth—probably within two per cent. In the last few years, the net annual increase has been given first as 1.3 per cent, then as 1.5 per cent, in 1958 as 1.6 per cent, and in 1959 as 48,000,000, or nearly 1.7 per cent. Thus, the world is adding unto itself a net population increase equivalent to the whole population of Australia in less than three months, of Canada in about five months, and of even crowded Britain in only a year. In twenty-four hours, the equivalent of a town of 130,000 is added to the total. In terms of birth rate—more than three every second—the position is still more alarming.

II

LAND AND PEOPLE

The immediate problem of population pressure on land can be studied on at least four levels. The first is the world or global level. Although it may be of interest to attempt to calculate how many people could be supported, with existing knowledge and techniques, on the earth's land surface, this is, in fact, of rather theoretical interest, because the world is far from being one united whole.

The second, or national level, is far more realistic. There are some nations rich in land resources, some rich in total area rather than usable land, and others rich from any point of view. It is difficult for an American, for example, from a country where labor rather than land is in short supply, to realize that for another country, where land is desperately short, it is output per unit area that matters and output per man-hour can almost be disregarded.

In the third place, most of the larger countries exhibit contrasts within their own boundaries. In some cases—Brazil and Australia are examples that spring to mind—the contrasts are extreme, and so regional planning becomes of national importance.

In the fourth place, there are the intimate land-people relationships that affect the siting of towns, and even of individual farms and homesteads. It should be the prime objective of physical planning to secure for the people the maximum advantages possible from an intelligent use of land. They need space for living, but their livelihood and the economic well-being of the community depend upon the right location for industry and commerce. Indeed, planned industrial location is often—even usually—the keystone for intelligent use of land. The people also need space for recreation, but if possible without sacrificing those scarce areas with soil and microclimate best suited for production of fruit and vegetables, milk, and other foods that are best when fresh-produced near home.

To take first the global situation, if the 2,900,000,000 people living today were each given an equal share of the earth's land surface, each would have some 12½ acres. But this would include appropriate proportions of the ice-covered polar lands, the arid deserts, and the great mountains. In general terms, about a fifth of the earth's land surface is too cold to support permanent settlement based on the cultivation of the land and the production of food, although there will be pockets of settlement based on the exploitation of minerals; another fifth is too arid and has no known water resources; another fifth is too elevated or mountainous; and another tenth lacks soil and consists of almost bare rock. This leaves about thirty per cent with adequate moisture, temperature, and soil to be potentially cultivable, and it has become usual to refer to this as the oecumene, or habitable earth's surface. The 12½ acres that is the share of each world citizen is thus reduced to four acres of potentially usable land.

How much is actually used at the present day? Taking the average of all the varied techniques of cultivation—the digging stick, the hoe, the ox-plow, and the huge mechanical cultivators, as well as the varied foodstuffs—it is about 1.1 acre per head. In other words, on a world average, it takes the produce of rather over one acre to support one human being. The parts of the cultivated lands used for nonfood crops—cotton, jute, oilseeds, rubber, and the many others—are counter-

TABLE I

ACRES OF LAND PER HEAD OF POPULATION

Area	Total Land	Potentially Cultivable	Actually Cultivated
World	12.5	4.0	1.1
United States	14.0	6.0(?)	3.5+
Canada	140.0	20.5	4.0+
Brazil	41.0	30.0	1.0 −
United Kingdom	1.1	0.6	0.55−
England & Wales	0.8	0.6	0.55−
Netherlands	0.8	0.6	0.55−
India	2.1	1.0	0.95
Pakistan	3.0	1.0	0.7
Burma	9.0	4.0	1.15+
Japan	1.1	0.2(?)	0.15
Uganda	10.0	9.0	1.0

NOTES: + indicates a normal surplus available for export.
− indicates a permanent deficiency in home supplies requiring supplement by import.

balanced by food contributed from the great grazing or range lands of the world. Even then, if the existing techniques were applied and all the "potentially cultivable land" were actually used, it would seem possible for the world to support four times its present population.

Against this world yardstick, it is interesting to compare individual countries. Some contrasted ones have been set out in table one.

When one is concerned with the basic land resources of any given country, it is worth while to see how it compares with the world as a whole or with one of the countries given above. Clearly a country with an abundance of land can enjoy certain advantages—wide roads, cloverleaf junctions, national and state parks, nature reserves—that can scarcely be contemplated in a country where pressure on land is already desperate as it is in so many of the crowded states of Europe.

III

THE MEASUREMENT OF LAND RESOURCES

The measurement of land resources, actual and potential, is an extraordinarily complex subject. If the purpose is to ascertain the maximum population that can be supported by the production of the world as a whole, or any given country, there can probably be no final answer, even assuming present technological levels. Necessity is ever the mother of invention: 3,000,000 people are now crowded into parts of the very hilly lands of Hong Kong and the New Territories covering in all only 391 square miles; yet, the Chinese market gardeners feeding almost pure sands with human, animal, and artificial manures can very nearly satisfy the needs for the vegetables that make up a major part of the people's diet. It takes the produce of over three acres of improved farm land to provide food adequate for a present day American diet; yet, the Japanese relying on high-calorie, high-yielding rice, deriving much of their needed protein from beans and much of the remainder from fish, manage to feed perhaps six or seven people from each cultivated acre. From this one point of view, Japanese agriculture is twenty times as "efficient" as American. Thus, the whole question of land resources and their measurement bristles with difficulties—the meaning of efficiency, the concept of carrying capacity, and the aim of dietary planning are but examples.

Taking first food production on a world basis, it would seem that at present, increase in output is rather more than keeping pace with population. Using FAO statistics, the position would seem to be that shown in table two. If, however, this world position appears satisfactory, it is far from being so in many countries. In contrast to the vast stock piles of foodstuffs that embarrass the United States and Canada, the people of India are getting less food per head today than they had thirty years ago.

In studying the question of the feeding of mankind, one of our objects must be to discover where diets are adequate, where they are inadequate. But diets vary

TABLE II

ESTIMATED WORLD PRODUCTION OF MAJOR FOODSTUFFS (MILLION METRIC TONS)

	1934-38	1948-52	1957-58
Wheat	95.0	113.5	122.4
Barley	28.5	36.0	49.7
Corn	94.1	119.6	137.6
Rice	70.2	74.8	88.2
Sugar	21.0	26.4	35.6
Meat	26.9	30.5	39.2
Farm products index	85	100	117
Population index	90	100	112

enormously, and it is always difficult to make comparisons between rice-eaters and bread-eaters, or between those relying largely on meat-milk-eggs and the vast numbers of almost pure vegetarians. In his presidential address to the International Geographical Congress at Rio de Janeiro in 1956, the writer introduced a measure that he called the Standard Nutrition Unit (SNU).

Even when seasons allow double or treble-cropping, the world's farmers think primarily in terms of an annual harvest, and so the unit chosen was one of annual farm output. Provided a diet is sufficiently varied, the intake of the minor but important elements well known to the nutritionist is likely to be adequate or can be easily supplemented if the basic quantity supplying calories for the daily working of the human machine is adequate. Although many nutritionists lay down a rule that half a daily minimum intake of protein of eighty grams should be *animal* protein—*i.e.*, meat—the fact remains that for more than half the world, the intake of animal protein is less than ten grams (one-third of an ounce) per day, and for the vegetarian quarter of mankind, it is negligible. We are on surer ground with caloric requirements, and so the writer chose a farm production of 1,000,000 calories per annum as the Standard Nutrition Unit. It does not matter whether the farmer is producing rice, wheat, corn, meat, milk, or other staples, his output can be converted into calories.

After farm output, there follows a deduction for seed and loss in milling and other forms of preparation and cooking. The average loss was calculated in several ways and approximated to ten per cent, so that the farm output of 1,000,000 calories per annum becomes 900,000 available for consumption. This is 2,460 calories per day, which may be accepted as a reasonable world standard for an "average" human being. A lower figure is adequate where people are lighter in weight than world standard and in hot countries and with diminution in physical effort. Detailed studies in Indian villages show 2,000 calories per day just adequate for maintenance of health; on the other hand, figures of 3,000 calories per day in North America and certain European countries include wastage of food after preparation that can be very high but cannot be calculated.

The Standard Nutrition Unit can be used in a variety of ways. First, by converting national total production of food into these units, one gets a measure of the adequacy or inadequacy of a country's total production. Second, it is a measure of efficiency in farming output between one country and another. It is here that we realize that some diets are much more extravagant of land than others. The multiple-cropped lands of Japan, with a dietic reliance on rice, yield six, seven, or even eight Units per acre. An intensively farmed acre of wheat in Northwest Europe yields four Units, but with the varied meat-milk-bread-vegetable-fruit diet of Britain, it takes rather more than one acre to produce one Unit—*i.e.*, to feed one person. Most extravagant of land is the meat diet and an extensive form of mechanized farming, with an output under North American conditions of about 0.3 Unit per improved acre. Some countries such as Spain and Australia have low outputs because of the vagaries of climate; others, such as India, because of the primitive level of farming techniques.

IV

THE NEW AGRICULTURAL REVOLUTION

This leads us to consider the developments taking place in farming all over the world—along many lines simultaneously and with such remarkable rapidity that the expression "new agricultural revolution" is not inappropriate.

Mechanization of agriculture is an obvious and world-wide phenomenon. The farm-horse, and incidentally his demand on land for his feed, is disappearing with incredible rapidity all over the world. Soon the horse will become, as it was in the Roman Empire 2,000 years ago, just a symbol of pomp and power for police and politicians. The fact that Britain can claim to be the most highly mechanized farming country in the world in terms of number of implements per farmed acre raises an interesting issue. Is the farming there, and elsewhere, already overmechanized? The world over, the farmer tends to be an individualist; an incorporated farming company is a rarity in the free world, and large-scale farming has its problems in other countries. The average British full-time farm is 100 acres—it would seem slightly larger than the American average—and every British farmer seems to be aiming to possess a full range of mechanical equipment, despite the fact that some machines may be used only for a few days in the year. Is this efficiency, or is it overmechanization? It would also seem that mechanization with machines at present available is not necessarily the answer in the tropics, where land management presents problems quite different from those in mid-latitudes. But there is no doubt that mechanization—and with it, marriage of town and country, farm and factory, farmer and mechanic—is playing and will play a major role in the agricultural revolution. With it goes road haulage and the improvement of access.

More recent than mechanization, but just as important, is the chemicalization of agriculture. So-called artificial fertilizers are applied to land in quantities undreamed of a few years ago. Minute quantities of certain trace elements have rendered fertile lands long regarded as sterile. Chemicalization is altering the whole relationship between the farmer and the land. The application of chemical manures may destroy the natural structure of a soil and the minute inhabitants of the soil—its flora and fauna—but at the same time, soil conditioners may break up a heavy clay soil and render it workable. In many cases, we are moving towards hydroponics, where a sterile mixture of mineral grains replaces a soil and nutrients are supplied as required by the crop concerned. In another field, fungicides and insecticides—indeed, sprays of all kinds—are very powerful weapons against many of the farmer's old enemies. The growing use of "weed killers"—selective herbicides—has opened up many difficult questions of the balance of plant and animal life, the danger of poisoning crops in neighboring fields, and of poisoning animals.

Chemicalization is linked in many ways with a third line of development—the work of the plant and animal geneticist, the breeding of strains that emphasize such desirable trends as a higher yield by exploiting hybrid vigor in corn, an early vegetative growth in grass, or a higher yield of milk from cows or eggs from hens. Artificial insemination, the preservation of semen over long periods in cold storage, and the manipulation of heat and light to vary the reproductive cycle are but some of the other current lines of research.

The actual reclamation of land by irrigation and drainage is extending the cultivable area, but there are still vast fields unconquered. It was primarily in the nineteen-thirties that the coincidence of an economic depression with a succession of bad seasons focused attention in the United States on the evils of soil erosion and all that stemmed from "dust bowl" conditions. The concept of soil conservation was put over with a bang—soil erosion must be stopped or the world would starve. It is true that much soil erosion, owing to the foolish haste of man in plowing up the grasslands or leveling the forests, is bad, but erosion as a whole is an inexorable process of nature. There would be no fertile valley-delta in Egypt to support 20,000,000 people if it were not for erosion in the mountains of Ethiopia; the Netherlands would scarcely exist were it not for past erosion in the Alps. It is high time that attention were focused on trapping and retaining the valuable material swept down by every muddy river in the world.

V

How Many People Can the World Support?

Although the proud boast in President Truman's Point IV declaration—"for the first time in history, humanity possesses the knowledge and the skill to relieve the suffering" of the half of the world living in misery, hungry and diseased—is not easily substantiated to the full, there is no doubt that the world can support many times its present population. We have scarcely begun to cultivate the seas systematically; but taking only the land areas, three times the land at present cultivated remains to be conquered. Difficult though that task may be, these are the lands with adequate water, heat, and soil. Where necessity demands, as many as 4,000 persons are being supported by the produce of a square mile of farm land against a world average of about 600 persons.

But this introduces quite a different idea. We can talk about the carrying capacity of land and say that with highly intensive subsistence farming as many as 4,000 persons per square mile may be supported. Farming, however, is rapidly becoming a highly scientific and specialized business. The farm must be adequately supplied with capital; the farmer must have the intelligence to use the knowledge and advice of experts, to know how to manage land, crops, livestock, and the tax collector; and his hired man must be a good mechanic and, if animals are involved, at least halfway to being a veterinarian. If this is true, the business of food production will gradually pass into the hands of experts. This has already happened in the more advanced countries, where the farming population has dropped to under ten per cent of the employed population, as contrasted with fifty to eighty per cent or more in many of the underdeveloped countries.

According to the admittedly imperfect figures published by FAO in 1950, agriculture still occupied fifty-nine per cent of the total population of the world, as compared with sixty-two per cent in 1937. Undoubtedly, the drop in recent years has been very rapid. Although Indian economists are worried by the slow improvement of agriculture, it is estimated from another point of view that changes in rural life have already sent 60,000,000 landless peasants drifting to the towns. A square mile of really intensively farmed land may support, as noted previously, a population of subsistence farmers and their families totaling 4,000, but the maximum *output* from that square mile under efficient commercial farming could probably be obtained by a total population of less than a tenth of that number.

There is certainly no doubt that efficiency in farming and the output of land involves a reduction in the labor force. This has been seen in operation over the past few decades in many countries, including Britain. We may hazard a guess that the present fifty-nine per cent of mankind engaged in or directly dependent upon farming could be reduced to ten per cent at the most. In a great primary producer like Canada, growing vast quantities of food for export, it was already down to sixteen per cent in 1956; in the United States, to thirteen per cent in 1955; in Belgium, to thirteen per cent in 1950; in the Netherlands, to fourteen per cent in 1950; and in Britain, producing half the food consumed, to five per cent in 1951.

The world's greatest problem may soon be not the difficulty of feeding the increasing population, but what to do with the hundreds of millions displaced by an efficient agriculture.