LAND USE MAPPING IN SUDAN

J. H. G. Lebon

Dr. Lebon contributed to the Land Utilization Survey of Britain in 1930–1935, and his report on Ayrshire forms Part I of "The Land of Britain." He has been Professor of Geography in the University of Khartoum since 1953.

In September, 1955, during the Symposium on Natural Resources, Land and Population in Tropical Africa held at Makerere College, Kampala, Uganda, Professor L. Dudley Stamp asked the author of this article to address a meeting on land use maps. In the brief talk which was thereupon prepared and delivered, it was stated that no land use maps for any part of Sudan existed; but certain local surveys had been executed, not primarily of land use, but which might serve as the basis of such. The general inference was pessimistic, for it then seemed quite impracticable to attempt to produce land use maps for a territory of nearly a million square miles.

However, the author, on his return to Sudan, gave further thought to the question, and decided to apply, experimentally, the World Land Use Classification to the country. Certain problems emerged, which will be stated later in this article, with their solutions; but, what was more important, it was realized that for a scale of 1:2M or 1:4M, it would be possible to draw a generalized and provisional map, showing land use types, by using certain published maps of vegetation types (to reveal the extent of unimproved grazing land), of such important bioclimatic factors as the limit of the tsetse fly (which constitutes a barrier to the southward extension of grazing), as well as the local surveys discussed at the Symposium. Also—and this was the last door which needed to be opened—it was realized that the topographic series at 1:250,000, the largest-scale series depicting the whole of the country, though essentially the product of reconnaissance survey, having been compiled from route sketches, local surveys, and the like, mainly by administrators and army officers in the early years of the Anglo-Egyptian Condominium (1899–1955), provides, on the whole, a reliable representation of inhabited areas. The early administrators needed to know, above all, where the people they ruled were to be found when they were "on trek," and thus they were especially careful to locate all villages. Now nearly all cultivated


3 Sudan, Vegetation Map, 1:4,000,000, Sudan Survey Department, Khartoum, 1955.


land falls into categories 4b or 7f(i) of the World Land Use system (i.e., land rotation or shifting cultivation), and occurs within a limited distance of villages, usually five to seven miles. Accordingly, when a map on a small scale is being compiled, the chief cultivated areas of the country may be delimited approximately by enclosing all areas within this distance of settlements.

The way was therefore open to compile a map on a scale of 1:3M, i.e., the largest scale for which a map has been printed on one sheet for the whole
country. This (first) provisional map for Sudan was exhibited at the Congress of the International Geographical Union held at Rio de Janeiro in August, 1956.

Meanwhile the author had occasion, for other reasons, to consult the air photograph collections of the Survey Department, Sudan Government, Khartoum. This Department, since the end of the War of 1939–45, has owned copies of the trimetrogon air photographs taken by the U.S.A.A.F. in 1942–3, when the trans-Africa supply route to the Middle East was being organized, and it was imperative to provide more accurate maps for air navigation. The photographs in this collection number about 60,000, and they portray the whole of the country north of latitude 8° N., except the extreme northwest. Since 1950, the Survey Department has itself been engaged in vertical photography. Some large tracts, including areas south of the 8th parallel, in the Nile swamps, the Red Sea hills, northern Kordofan, and southern Darfur, have thus been photographed; and the total of Sudan Government vertical photographs (to April, 1957) is about 113,000. It was discovered that trimetrogon, as well as vertical photographs, permitted highly accurate plotting of cultivated areas; and it was, therefore, decided to attempt, also, to map on the normal scale prescribed by the World Land Use Inventory, viz., 1 to 1 million. Only one sheet of this series (El Fasher, ND 35) has been revised from air photographs and published; but it includes significant portions of the main cultivated and pastoral zones of central Sudan. The task of inserting land use boundaries on this sheet was begun in the autumn of 1956, and finished in March, 1957, after about 8200 photographs had been inspected. Minor revision of its extreme southwest, from vertical photographs which had meanwhile been produced, was undertaken in August, 1957.

The completion of the El Fasher 1:1M sheet enabled the Provisional 1:3M map to be revised for about one-eighth of the country; and the author decided also to use trimetrogon photographs for the purpose of revising those features which he regarded as least satisfactory, viz., the delimitation of the desert border and the transitional zone of desert-sparse grazing (denoted by the symbol 6a'-9). This was accomplished in September, 1957; and he was able also to effect further minor revision in the center and south from population maps which Mr. K. M. Barbour had been preparing at University College, London, using the results of the First Population Census of Sudan, 1955–1956. Thus, eventually, was produced the Revised Provisional Land Use Map of Sudan, on the scale of 1:3M, of which the map accompanying this article (Fig. 2) is a generalized version.

It is expected that this (revised) map will be published on a scale of 1:4M, together with the El Fasher 1:1M sheet, and the author is writing a memoir which will embody a lengthier analytical account of the two maps. In this short article, the facts disclosed by the Revised Provisional Map will be briefly discussed.

The Essentials of Climate, Natural Vegetation, and Relief

Sudan is typically African. It is a tableland, upwarped in some places, down in others. Quite locally, hills and mountains rear out of the monotony. The transition from a near-equatorial climate on the southern frontier (annual rainfall about 60 inches
and dry season two to four months) to the desert (annual rainfall almost zero) at about 20° N., through the gradations of the tropical continental climate, in which rainfall and length of rainy season vary inversely with latitude, is only locally distorted by relief, perhaps to the greatest extent in the extreme southeast, which, situated as it is in the angle between the Ethiopian and the East African uplands, is notably dry for its latitude. Concomitantly, the equatorial rain forest, extending across the frontier from Belgian Congo in the southwest, merges into semi-deciduous forest with tall grass and this in turn into acacia scrub with tall grass, sparse acacia with short grass, semi-desert, and desert.

On the basis of relief and geological formations, a number of physiographic or relief regions may be discerned (Fig. 1). These are demarcated on the map and distinguished by Roman numerals to avoid confusion with land use notation; and a description of each region will now be given, seriatim.8

I. The Western and Southern Plateaus. Here, along the upwarping separating the Nile Basin from those of the Congo and Lake Chad, the exposed basement complex has been dissected by a dendritic network of main and tributary streams. The larger valleys often have alluvial floors. The interfluves, in the southwest, are usually capped by laterite, and here the name Ironstone Plateau is applied (Ia). Inselbergs are not uncommon, rising 500–1000 feet above the general level of 1500–2500 feet. Near the frontier with Uganda are the higher massifs of the Imatong Mountains, the Dongotona Hills, and other smaller uplands, which, perhaps, should be regarded as relief sub-regions. In western Darfur, beyond an extension of Region V, archaean rocks reappear and display similar features of relief and soil (Ib).

II. From Juba to beyond Khartoum, the Bahr-el-Jebel and the White Nile cross an alluvial plain, which has been accumulated in a pear-shaped, downwarped area. On either hand, in the south, the rivers from the Ironstone Plateau (to the west) and Ethiopia (to the east) contribute their loads to the continuing alluviation. Such is the degree of aggradation that slopes are too small to permit rivers to carry their full discharge in the rainy season to the Nile, or to allow rainfall to reach watercourses. Thus south of about latitude 10° N. the whole plain becomes a swamp during the rainy season (IIa). During the dry season, the excess of water disappears, and as a whole the region is dry, fire-swept, and waterless; but there are permanent marshes along the main rivers and in certain other localities. North of latitude 10° N. rainfall is less, and only local waterlogging occurs during the short rainy season (IIb). Also, the plain is diversified by inselbergs, which were not quite submerged in the deepening alluvium.

III. The frontier, in principle, separates the Sudanese plains from the Ethiopian mountains; but has been demarcated so that certain detached massifs, spurs and foothills, of which the most important are the Boma Plateau and the hilly environs of Gallabat, fall within Sudan.

IV. West of the White Nile is another area in which the basement complex is exposed, and from which inselbergs and massifs arise, often abruptly: collectively known as the Nuba Mountains. The largest of these measures about 45 by 15 miles, and the highest summit reaches 4691 feet (Jebel Tema-
Fig. 2. Land use of Sudan. Numbers and letters of legend have reference as follows:

4a. Continual and rotation cropping.
4a'–6a(7c). Cropping on flush-irrigated land, with used unimproved grazing in scrub.
4a''–6a(7b–c). Terraced cultivation in mountains, with used unimproved grazing in semi-deciduous forest (with grass) or scrub (with short grass).
4a'''–6a(7b). Continual cropping with some unimproved grazing, in semi-deciduous forest with tall grass.
4b–6a(7b–c). Land rotation with used unimproved grazing, in semi-deciduous forest with grass, or scrub with short grass. (The small circles locate areas too small to contain the regular ornament.)
6a(7b–c). Used unimproved grazing, in semi-deciduous forest with grass, or scrub with short grass.
6a(8'). Used unimproved grazing in seasonal swamp (mainly tall grass, but with some scrub and scattered trees). The broken lines outline the late dry-season grazing lands.
7a(e). Dense (closed) evergreen forest.
LAND USE MAPPING IN SUDAN

7b(sd). Open semi-deciduous forest (with tall grass).
7c(sd). Semi-deciduous scrub (with short grass).
7f(i)(e–sd). Evergreen and semi-deciduous forest with shifting cultivation.
8. Swamp.
6a'–9. Mainly desert, with some used unimproved grazing. ("a" omitted from symbol on map.)

ding). Each inselberg or massif is fringed by a pediment veneered by detritus of varying texture; and the larger watercourses flow in silty or clayey flood plains.

V. North and west of the Nuba Mountains, and reaching the White Nile between Jebelein and the Sixth Cata-ract, is a region mainly of sand dunes, formed during a (presumably) Pleistocene dry period from the weathering of the great outcrop of Nubian sandstone to the north, and now fixed by acacia trees and grass. These Dunes at their deepest (along the boundary between Kordofan and Darfur), are without surface drainage; elsewhere, watercourses are attenuated and imperfect.

VI. West of the Dunes, and rising from the basement complex in central Darfur, is the volcanic massif of Jebel Marra, with which may be associated the detached massif to the northeast, known as the Meidob hills. The summit of the Jebel Marra (9980 feet) is on the rim of an extinct volcanic crater containing two lakes. Adjacent are high plateaus of lava and tuffs, dissected into badlands. Detritus from these volcanic uplands has descended in the flood waters of torrents and has formed silty, fertile piedmont plains.

VII. The Red Sea littoral is low, and consists of raised coral reefs and active dunes (VIIa); but inland, at a distance of from 10 to 25 miles from ocean water, is a dissected fault-line escarpment, compound in places, marking the western edge of the Red Sea rift valley. This escarpment rises to between 2000 and 4000 feet, and is succeeded, in turn, by the broken and rugged Red Sea hills (VIIb), which attain over 7000 feet, though most summits are between 3000 and 5000 feet. Some rather lower parts are more plateau-like.

VIII. North of the Dunes and west of the Red Sea hills is desert; called, east of the Nile, the Nubian Desert, and to the west, the Libyan. Both deserts are diversified, and contain inselbergs, rocky massifs of archaean crystalline rocks, buttes and mesas of Nubian sandstone, rocky or gravelly plateaus and great expanses of active dunes, especially west of the Nile and north of latitude 18½° N. On the margins are a few intermittent watercourses which, however, owe their existence to rains falling to the south and southeast.

LAND USE TYPES AND THEIR DISTRIBUTION

Several categories of land use specified in the classification of the World Land Use Inventory are unrepresented in Sudan, or appear to a very limited extent. On the scale of the present map (Fig. 2), category 1 (settlements) cannot be delineated, because there are no large urbanized tracts such as are to be found in industrialized countries, and even the capital, Khartoum, and the adjoining Omdurman, occupy only a few square miles. Horticulture (category 2) and tree crops (category 3) occur only locally. The small plots of onions and other vegetables grown under irrigation from the Nile near Khartoum and Atbara; the small market-gardens watered from wells at Kassala; the government-owned citrus fruit orchards in some irrigated basins of Northern Province, and smaller orchards planted
by peasants; the clusters and strips of date palm close to the River—could only be represented on a scale of about 1:5,000. Improved permanent pasture (category 5) is again absent.

Slightly more extensive, but still small in proportion to the country as a whole, are areas of continual and rotation cropping (type 4a), of several kinds. Along the Blue and White Niles, north of latitude 12° N., and continuing northward along the main Nile to the Egyptian frontier, are areas watered artificially by flow or by pumping. The larger units, irrigated by pump, or by gravity from the Sennar Dam, can be delineated from the 1:250,000 maps. Where farming depends upon the shaduf or the Persian water-wheel, the strip of cultivated land must be exaggerated in width to be shown on the present map; but this has been done to indicate that tillage is almost unbroken from Khartoum to the frontier. For such irrigated areas, the symbol 4a is used.

It may be concluded from the foregoing statements, and correctly, that types of land use characteristic of middle latitudes (and more densely settled lands) have barely intruded into Sudan. All areas so far specified are in the northeast, and may be regarded as extensions, along the Nile routeway, of types of agriculture dominant in middle latitudes. And their tropical equivalents are also absent, or almost absent, from the country. In short, the prevailing types of land use in Sudan, outside the unproductive desert of the northwest, type 9, are those characteristic of the humid African tropics. As already stated, land used for crop production is in land rotation, type 4b, or shifting cultivation, type 7f(i). The remainder, largely, is used unimproved grazing land, type 6a. Smaller in proportion, but nevertheless of great extent in so large a country, are forested lands, in the far south, which are uninhabited or used only for the production of timber (types 7a and 7b).

Two important facts must now be noticed. First, these dominant types of cultivation and pastoralism do not cause replacement of existing vegetation, but only its modification. Both land rotation and shifting cultivation rely upon regeneration of the natural vegetation as the means to renew fertility after cropping. The patches of cultivation are like islands in a sea of reviving forest or scrub; though unlike most islands they change in position and size from year to year. Secondly, most of the country, between the desert in the north and the northward limit of the tsetse fly in the south (to be correlated roughly with the northern edge of the Ironstone Plateau), is used by nomadic and semi-nomadic pastoralists who travel far during their customary seasonal migrations seeking pasture and water. Moreover, pastoral use of land comprises most areas of land rotation as well as those lying outside, because the stock of cultivators grazes upon much of the stubble and regenerating vegetation, though not upon all. On the scale of the present map, and by the methods of compilation used, it is not possible to distinguish between cultivated areas which are also used for grazing (the greater fraction), and those which are not (chiefly those which are managed as hariq or by the grass-firing system).  

These two facts in turn led the author to certain adaptations of the World Land Use system of classification and symbols. First, the symbol 4b was combined with 6a, because of the superposition of pastoral uses upon land rotation. Secondly, and because no permanent replacement of natural vege-

---

LAND USE MAPPING IN SUDAN

67

Station results from these methods of cultivation and grazing, the original type of natural vegetation has been appended to certain subsidiary 4a types, to 4b, 4b-6a, and 7f(i). This, it is believed, enhances the value of the map, since it indicates, to those familiar with African vegetation, the nature of the regenerating plant mantle. The combined symbols thus resulting have been considered as separate categories of land use for the purpose of delimitation. It will be shown later that there is a further advantage to be derived from this expedient, for Sudan, because areas over which different types of pastoralism prevail can be distinguished.

If the map (Fig. 2) is now scrutinized, it will be observed that land rotation prevails in a zone extending across the country from east to west, between about latitudes $10^\circ 12'$ and $14^\circ 12'$ N. This zone is usually called the Central Rainlands. It crosses the northern Clay Plain (relief region IIb), includes much of the Dunes (IV) and the Nuba Mountains (V), envelopes the Jebel Marra (and indeed penetrates to the higher altitudes therein), and continues across western Darfur to the frontier with French Equatorial Africa. The northern limit is imposed by aridity near the annual isohyet of about eight inches. The southern limit corresponds with an annual rainfall of about 25 inches and a rainy season lasting four to five months, during which the predominating clay soils are waterlogged and domestic animals suffer severely from biting flies. The staple of the Central Rainlands is millet, in one of two forms, the common millet (Sorghum vulgare) or bulrush millet (Pennisetum typhoideum) (Burm.) (the latter especially in sandy soils), both of which can flourish where rainfall is light and intermittent.

The length of rotation varies. It is shortest on lands near villages, called bildat, on which cultivation is almost perennial, with but brief resting periods. On hariq lands (mainly in relief regions IIb and IV) one or two years of cropping are succeeded by fallow for two to four years. In gum arabic “gardens” tillage for two to six years is followed by regeneration for six to twelve years during which Acacia Senegal and A. Seyal grow freely and are tapped.10

Farther to the south, it will be observed, land rotation is practiced on smaller areas, near the main rivers and close to the Ironstone Plateau in the southwest, within relief region IIa. These areas are slightly higher than the clay plains generally, and hence are usually above the otherwise ubiquitous swamp of each rainy season. To these islands the Nilotic tribes—Dinka, Shilluk, Nuer, Murle—retreat as waters spread over most of their land, and here they break ground and sow crops of millet.11

To the prevalence of land rotation as the type of cultivated land use north of the tsetse fly belt and away from the Nile, three local exceptions may now be noticed. (1) Among the torrents which descend from the northern Ethiopian highlands are two, the rivers Gash and Baraka, which have formed silty deltas, the former northwest of Kassala, the latter on the Red Sea coastal plain near the Eritrean frontier. Both torrents have been brought under control, and their deltas used in part for growing cotton. For areas thus subject to controlled flush irrigation and annual cultivation, the symbol 4a′–6a(7c) has been used, though it should be realized that the actual areas cultivated vary from year to year, and depend upon the size and character of the flushes, as well


as changes in level produced by deposition of silt.12 (2) In the Nuba Mountains13 and the Jebel Marra,14 Nuba and Fur peoples have long practiced types of terraced agriculture, the latter in conjunction with shifting cultivation and irrigated gardens from small perennial streams. The separate areas thus cultivated are too minute to be delineated on the map; but the massifs within which these types of land use occur are indicated by the symbols 4a''–6a(7b) or 4a''–6a(7c) for the Nuba Mountains, and 4a''–6a(7b) for the Jebel Marra. (3) At the extreme southwest of the clay plains, near Aweil, western Dinka are very numerous, and are crowded onto land just above flood level along the lower Lol and Kyom rivers, and on islands in the seasonal swamps. They have insufficient land to practice land rotation; and cultivate perpetually, maintaining fertility by tethering cattle and thus ensuring that the soil is impregnated with excreta.15 Congestion doubtless has thus required of the people to transform land once (it may be inferred) used on a rotation basis to continual cropping, from 4b to 4a''–6a(7b).

On the Ironstone Plateau of the far southwest, and to a more limited extent east of the Bahr-el-Jebel and close to the frontier with Uganda, is a zone, which, untouched by the hand of man, would bear either rain forest (7a) or semi-deciduous forest with tall grass (7b). Much of this zone, west of the Nile, is virtually uninhabited as a consequence of the depredations of slave raiders from the north during the 19th century. Where it is inhabited, by a variety of Negroid tribes, shifting cultivation is the norm; although an attempt has been made in the last decade to resettle the Zande people, who occupy land close to the frontier with Belgian Congo between Yei and Tembura, near roads and on demarcated plots on which, it is intended, permanent homesteads shall be established and land rotation eventually replace shifting cultivation.16 It is too soon to be certain that the economy has thus been changed; and so the area has been classified as 7f(i), which is appropriate to the traditional mode of life. East of the Bahr-el-Jebel, permanent settlements have been founded under the guidance of the administration at the foot of isolated hills, from which descending surface and sub-surface water maintains not only domestic supplies but also keeps the soil moist after rather light and erratic rains. Adjacent cultivation is on the basis of land rotation rather than shifting cultivation, but the areas are too small to be shown on the map.17

Used unimproved grazing land (6a) is the most extensive of all land use categories. It stretches from the desert in the north to the northern limit of the tsetse fly in the south, over about 12° of latitude. This great tract may be subdivided into five zones.

14 Ibid., pp. 867–872.
16 Ibid., pp. 906–908.
1. The plant mantle is not continuous along the margin of the desert. Indeed, it is most discontinuous within a crescent-like area 80–150 miles wide, where most of the surface is bare rock, sand, or gravel; but patches of scrub and grass occur, edible to camels, especially in the gravelly or silty beds of intermittent watercourses, which are numerous in and to the west of the Red Sea hills (relief region VIIb). On the higher plateau of northern Darfur, the scanty rains nourish a type of grazing known to the Arabs as gizu\(^\text{18}\) consisting mainly of the grasses *Aristida ciliata* (Desf.) and *Indigofera arenaria* (Rich.), which, according to Arab belief (to some extent confirmed by scientific research) are more nutritious dessicated than when growing. Gizu also includes more succulent plants and small shrubs which enable camels to survive without recourse to drinking water till quite late in the dry season. Patches of this type of grazing have been observed by travellers and noted on 1:250,000 sheets as far north as latitude 19. But desert is predominant; and to extend type 6a beyond the limit of more or less continuous vegetation would be misleading. Accordingly a combined index (6a’–9) has been devised and applied where desert predominates, but is interspersed by patches and strips of gizu. In terms of the categories of vegetation types, the 6a’–9 crescent corresponds with the desert scrub; but it has been demarcated more accurately, after recourse to air photographs, than on previously published maps.

2. To the south is a zone of continuous or near-continuous vegetation, of the acacia-short grass type, characterized by a variety of genera, though *Aristida* is perhaps the commonest. Rainfall is too small for cultivation, except where run-off, in the valleys of watercourses or at the foot of rocky hills, locally concentrates water in the soil. This zone provides the chief pastures for Arab camel-owning nomads, who move northwards towards the desert during the rainy season, and in general southwards during the dry season.\(^{19}\) These tribes also rear sheep and goats.

3. Farther south, again, are the Central Rainlands, already described, in which small areas of 6a interdigitate with larger areas of 4b–6a. Nomadic herding merges here with the stock—cattle, goats, sheep, asses and some camels—of sedentary village cultivators. Some tribes are partly nomadic and partly sedentary. There are complicated customary arrangements regulating the use of water sources and pastures at different seasons and by different groups. Broadly speaking, however, the animals belonging to nomads do not come near villages, where grazing is reserved for the cultivators’ stock. Around all larger villages, intense grazing by animals, as they pass to and from more distant pastures, and firewood cutting, have produced local deserts generally called ‘village perimeters.’ Around towns, these devastated and unlovely stretches are even bigger, and only at a few points, e.g., En Nahud and El Obeid, have control and replanting been attempted.


4. Again to the south is a zone which is mainly uncultivated and without a settled population; broad in southern Darfur, southwest Kordofan, and between the Nuba Mountains (IV) and the White Nile; somewhat discontinuous south of the Nuba Mountains and on the Clay Plains (IIb). In this zone, the Dunes (V) and the piedmont alluvia of the Nuba Mountains merge into clay plains, except east of the White Nile, where there is clay unrelieved. In general, this zone may be deemed to be the grazing area of the cattle-owning (Baggara) peoples during the dry season.20 As the rains cease, they move southwards, seeking water and fresh herbage, until, after February, they are located along the Bahr-el-Arab (or even beyond), the Machar marshes and the river Sobat. When the rains begin, men and beasts move northward quickly to escape biting flies and, in the clay areas, mud. Thus, during the rainy season, this zone is virtually uninhabited, apart from some Dinka, whose pastoral practices conform to those of Nilotic tribes generally (vide infra).

5. The southern Clay Plains (relief region IIa) are the domain of the Nilotic tribes, also cattle-herders, but owning different breeds from the Baggara, and practicing different methods of rearing. In the rainy season, which in these latitudes lasts for six or seven months, when so much of their homeland is a swamp, men and animals retreat to higher and drier patches, or to the edges of the Ironstone Plateau, lingering on the way to enable their cattle to feed on new grass produced chiefly by the species Hyparrhenia rufa. They tether their cattle at night in their rainy-season settlements, lighting dung fires to keep insects at bay, and smearing their own bodies with ashes.21 Also, they till the soil (vide supra). As the rains cease, they return slowly across the drying swamps, which they fire, to destroy the rank growth of the rainy season, now dead, and to encourage a limited regrowth from the moisture in the soil. Eventually they reach the flood plains of the perennial rivers, adjacent to the permanent marshes, accessible because of the normal fall of the rivers and bearing a growth mainly of the Echinochloa spp. of grass. Here they remain until the rainy season is heralded and the annual cycle recommences. These late dry-season pastures are outlined on Figure 2 by broken lines.

Acknowledgments

The author is indebted to Dr. S. G. Willmott, University of Durham, formerly of Yambio Agricultural Research Station, Equatoria Province, and Dr. G. Worrall, Faculty of Agriculture, University of Khartoum, for criticism and advice.

20 Ibid., pp. 668–670.