Chapter 2
Standardized land cover for T&T decision-making

In Chapter 1 the land cover of tsetse habitat was studied at continental scale by means of the GLC2000 of Africa. Global Land Cover 2000 is a multipurpose dataset, meaning that it was not created for a specific use but rather for a wide variety of applications. For the purpose of studying tsetse habitat and supporting T&T intervention the legend used in GLC2000 is not the ideal one; in the present chapter we try to define a more appropriate legend, using as a basis the datasets produced by the FAO Africover project. Even though the legend was created by aggregating some hundreds of land cover classes available in the Africover maps of east African countries, the legend is general enough to become a standard for T&T, valid for the whole continent. As is the case for GLC2000 and Africover, the proposed standard land cover for T&T is also based on the LCCS. Some general information about Africover and ensuing initiatives is given below.

HIGH RESOLUTION LAND COVER MAPS: AFRICOVER AND GLOBAL LAND COVER NETWORK

The purpose of the Africover project was to establish a digital georeferenced database on land cover and a geographic reference for the whole of Africa. The eastern Africa module was the first operational component of the Africover project and it was part of FAO assistance to countries involved in the Nile Basin initiative. The project was operational from 1995 to 2002 and the main output was the production of standardized land cover maps for ten countries[5]. From the methodological standpoint, Africover promoted the development of the LCCS, adopted by FAO and UNEP as the international standard for land cover classification and currently on its way to becoming an ISO standard.

The Global Land Cover Network initiative stemmed from the Africover Project; GLCN is a global alliance for the production of standardized, multipurpose land cover data worldwide; GLCN is now envisaging the production of land cover maps of several African countries[6] (Figure 6). The map of Senegal should be completed by the end of 2007.

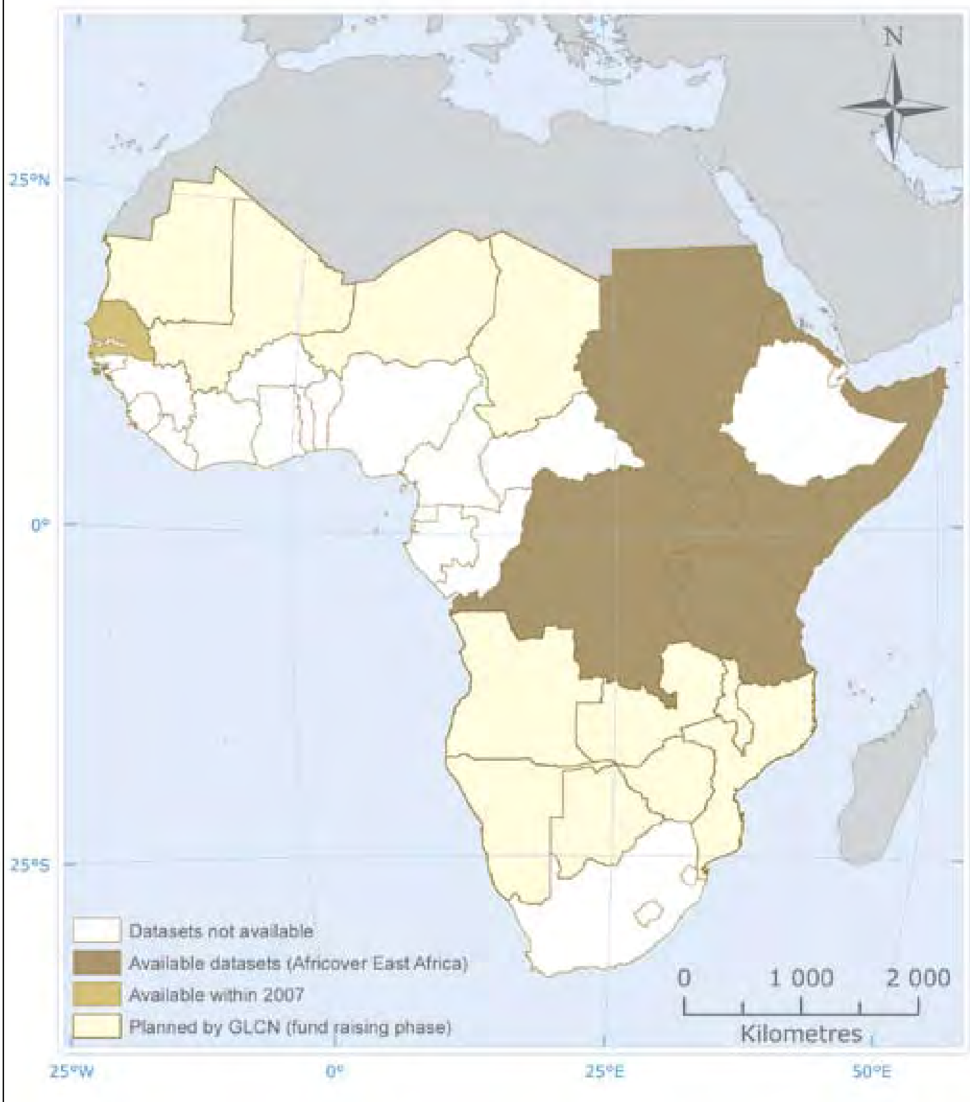
Africover products

For each project country, the most detailed land cover map produced by Africover is the ‘Full resolution multipurpose land cover database’. The maps are on a scale of 1:200 000 or 1:100 000, respectively for large or small countries (or specific areas of

[5] Burundi, Democratic Republic of the Congo, Egypt, Eritrea, Kenya, Rwanda, Somalia, Sudan, United Republic of Tanzania and Uganda.

[6] Angola, Botswana, Chad, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Zambia and Zimbabwe.

FIGURE 6
Availability of LCCS-compliant, high resolution land cover datasets in sub-Saharan Africa



interest in a country, e.g. the Nile river delta). The geodetic datum is the World Geodetic System 1984 (WGS84), the cartographic projection is Universal Transverse Mercator (UTM), and the planimetric accuracy of land cover polygons is 100 m. The land cover was produced from visual interpretation of digitally enhanced LANDSAT TM images (Bands 4, 3, 2). The land cover classes were developed using LCCS. In the 'Full resolution multipurpose land cover database' no minimum mapping unit (the smallest area that can be shown on the map) was set; therefore very small polygons measuring a few hectares are also present.

FAO Africover distributes a public domain, spatially aggregated version of the full resolution land cover dataset. The thematic content of the spatially aggregated dataset is very similar to the original one; the aggregation is performed at a spatial level, setting a threshold under which the polygons are dissolved into adjacent polygons.

On the Africover website[7], three predefined thematic aggregations (agriculture, grassland, woody), all based on the original 'Full resolution multipurpose database', are also available. In general terms, thematic aggregation is the procedure for customizing the Africover database to fulfil specific requirements. The Africover database gives equal levels of detail to agriculture as well as to natural vegetation or bare areas etc. A single user normally does not need a high level of detail for each class type; therefore they will enhance the information of one land cover type and will generalize or erase the information related to other land cover aspects.

Dissemination policy

The national databases developed by Africover are the property of each country; the NFPIs are responsible for the maintenance, update and distribution of the national databases. Specific data access policies have been developed in agreement with the NFPIs for the different types of datasets. The 'Full resolution multipurpose land cover database' is deposited in the NFPIs; FAO Africover also acts as a repository of the full resolution dataset and can access it for specific purposes. The authorization to access the full resolution database must be granted by the NFPIs. On the base of an agreement with the participating countries, FAO Africover distributes free of charge the spatially aggregated version of the full resolution database. Starting from the public domain Africover database, users can develop their own aggregations to satisfy specific information needs.

Thematic aggregation: basic concepts

Either the 'Full resolution multipurpose database' or the 'Spatial aggregation' can be used to perform customized thematic aggregations to better meet the requirements of the final user. Thematic aggregation is the process through which the original richness of the database is reduced in order to highlight the features that are relevant for the user and to drop all unnecessary information. The production of land cover maps for tsetse habitat mapping presented in this chapter was carried out through thematic aggregation of the 'Full resolution multipurpose databases' of eight T&T affected countries.

The most powerful way to conduct an aggregation is to use the classifiers as basic elements of the exercise. This gives the user the maximum flexibility on the use of data. The aggregation procedure follows three main conceptual phases:

1. Identification of the classifiers needed for the data customization.
2. Identification of the thematic classes containing the selected classifiers.
3. Creation of the aggregated classes taking into account the Africover cartographic standards.

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[7] www.africover.org

In the Africover database, because of the Minimum Mappable Area (MMA) chosen, the concept of mixed unit and the inherent characteristics of the study area, land cover class 'A' can be spatially represented in different ways:

- As a single map unit: A
- As a mixed map unit where 'A' is the dominant feature (more than 50 percent of polygon area): A/B;
- As a mixed map unit where 'A' is not the dominant feature (from 20 to 49 percent of polygon area): B/A; and
- As a mixed map unit were 'A' is not the dominant feature (from 10 to 20 percent of polygon area): B/A (this is valid only for 'isolated agricultural fields').

Owing to the fact that in Africover a mixed unit can have up to three classes A/B/C an aggregation class (called 1) can be represented in four (five for agriculture) different ways:

- 1 (were 100 percent of polygon area represents the aggregation class);
- 1a (60 percent approximately);
- 1b (40 percent approximately);
- 1c (20–30 percent approximately); and
- 1d (15 percent approximately. Only for agriculture).

In the aggregated map of Uganda presented in Chapter 3, the above possible combinations of mixed units were used to weight the contributions of different classes within mixed units in the assessment of tsetse suitability (see Figure 27, p. 57).

DEFINING A STANDARDIZED LEGEND FOR LAND COVER MAPPING IN T&T DECISION-MAKING

The standard legend proposed in this chapter was defined through the customization of eight out of ten national Africover databases currently available over East Africa[8] (i.e. the eight T&T affected countries). In the proposed methodology, based on thematic aggregation, one single legend is used to describe the land cover of all countries; the legend is composed of 26 classes (Table 7) that summarize more than 500 classes of the original databases. The aggregated classes have been defined with a view to depicting tsetse habitat across several countries in a harmonized and coherent manner.

One guiding principle for the definition of the legend has been the detailed description of natural vegetation, which is of prime importance in studies of tsetse habitat; 17 out of the 26 classes describe natural primarily vegetated areas, either terrestrial or aquatic. Two major LCCS classifiers have been used to define the natural vegetation: 'life form'[9]

[8] Burundi, Democratic Republic of the Congo, Kenya, Rwanda, Somalia, Sudan, United Republic of Tanzania, Uganda.

[9] *Life form* of a plant is defined by its physiognomic aspect: 'woody' life forms are distinguished from 'herbaceous' life forms. The woody life form is subdivided into 'trees' and 'shrubs'. A condition of height is applied to separate trees and shrubs. Plants higher than 5 m are classified as trees. In contrast, plants lower than 5 m are classified as shrubs (these general rules are subjected to the following exception: a plant with a clear physiognomic aspect of tree can be classified as tree even if the height is lower than 5 m but more than 3 m). A special class, called 'woody', has been created for plants included into the 2–7 m range, when no further

TABLE 7
Legend of the land cover map of East Africa for T&T (derived from Africover maps)

	MapCode	Class name (User Defined Description)	LCC User Defined Label
	1	Forest plantations and tree plantations	T
	2	Shrub crop	S
	3	Herbaceous crops	H
	4	Vegetated urban areas	5UV
	5	Forest	2TC
	6	Woodland	2TP
	7	Closed woody vegetation	2WC
	8	Open woody vegetation	2WP
	9	Thicket	2SC
	10	Shrubland	2SP
	13	Tree savannah	2H7
	12	Shrub savannah	2H8
	11	Grassland	2H(CP)
	14	Sparse trees	2TR
	15	Sparse shrubs	2SR
	16	Sparse herbaceous vegetation	2HR
	17	Fields rice	GZ-r
	18	Closed swamp	4TC
	19	Open swamp	4TP
	20	Woody vegetation on flooded land	4W
	21	Shrubs on flooded land	4S
	22	Herbaceous vegetation on flooded land	4H
	23	Artificial surfaces	5
	24	Bare soil	6
	25	Water bodies	W
	26	Snow	8SP

and 'cover'[10]. These two classifiers are considered to be the most relevant in determining the suitability for tsetse of different vegetation types because they describe the height and structure of the individual plants (life form, i.e. physiognomy) and the density of the vegetation (cover).

With respect to cultivated areas, the only distinction is made between tree, shrub or herbaceous crops. In the original databases detailed information is available on field size, cultural practices (e.g. rainfed, irrigated, etc.) and crop species; if need be, this information could be retrieved from the original databases to arrange a different type of

definition into tree or shrub is specified. The 'woody' class can be applied basically in two cases: the vegetation is an intricate mixture of both trees and shrubs which cannot be distinguished and with height included in the 2–7 m range; the user is not interested in further subdivision into trees or shrubs or has no information about it.

10 Cover can be considered as the presence of a particular area of the ground, substrate or water surface covered by a layer of plants considered at the greatest horizontal perimeter level of each plant in the layer (according to Eiten, 1968). A distinction is made between 'closed' (>60–70 percent), 'open' (between 60–70 and 10–20 percent) and 'sparse' (<10–20 percent but >1 percent). As herbaceous plants are seasonal in character, cover is always assessed in terms of fullest development.

aggregation. Further information on the land cover classes listed in Table 7, such as the standard definition of classes according to LCCS and the LCCS classifiers used, can be found in Annexes 1 and 2.

Figure 7(d) shows the Africover land cover customized for T&T decision-making over a small area 35 km west of Kampala, Uganda. The map legend reports only the land cover classes relevant to the area depicted. In the map, polygons are coloured on the basis of the main land cover, while a slash symbol, '/', separates the codes of mixed polygons in the labels. In Figure 7(a), (b), and (c) the satellite imagery upon which the maps is based is presented. The panchromatic band (15 m resolution) is displayed in greyscale, 7(a), in true colours, 7(b), is the Red–Green–Blue (RGB) composite of bands 3, 2 and 1 (30 m resolution), in false colours 7(c) is the RGB composite of bands 4, 3 and 2. (Band 4 of Landsat 7 satellite is sensitive to the near infrared band of the electromagnetic spectrum and is particularly useful for vegetation monitoring.)

Given that the proposed legend derives from the thematic aggregation of the land cover classes of the Africover maps (see table of class aggregation in Annex 3), it is straightforward to derive the standardized maps for T&T decision-making for the eight countries available in the Africover dataset (Figure 8). For the sake of clarity, in these graphic representations each land cover polygon was given the colour of its main class only (i.e. in these maps, patches characterized by mixed cover cannot be distinguished from pure polygons).

Figures 9 to 15 are the national maps used to create the seamless regional mosaic in Figure 8.

The proposed legend has tsetse habitat mapping and T&T intervention as its major targets. For studies of a different nature it might be more useful to define other aggregations. If mapping trypanosomiasis risk were the final goal, the interface between natural and managed areas could be analysed in more detail; for instance, in the Africover datasets it is possible to highlight the presence of scattered or isolated cropped areas in a matrix of natural vegetation. More in general, Africover datasets are capable of depicting varying degrees of intermixing between cropped areas and natural vegetation. These zones of transition between natural and managed areas are the ones were risk of contact between vectors and cattle or men is at its highest (de la Rocque *et al.*, 2001) and they should be the target of more intense T&T control actions. A closer look at the spatial pattern of natural and managed areas could also be used to study tsetse habitat fragmentation due to human encroachment.

The proposed classification is not only aimed at the customization of existing Africover datasets, but it can be used also within ad hoc land cover mapping exercises carried out in the framework of T&T research and control activities. It could also be applied to upcoming datasets produced within the framework of the GLCN, possibly with minor adaptations.

It is very important to stress that the use of the legend in Table 7 is not sufficient for a land cover map to be compliant with the LCCS. The definition of each class in LCCS must be fully understood. Some details on the classes definition can be found in Annexes 1 and 2, while for further specific information the reference text is 'Land Cover Classification System – Classification concepts and user manual – Software version 2' (FAO, 2005).

FIGURE 7
(a), (b), (c) Satellite imagery acquired by Landsat 7 and (d) Africover land cover map derived from it

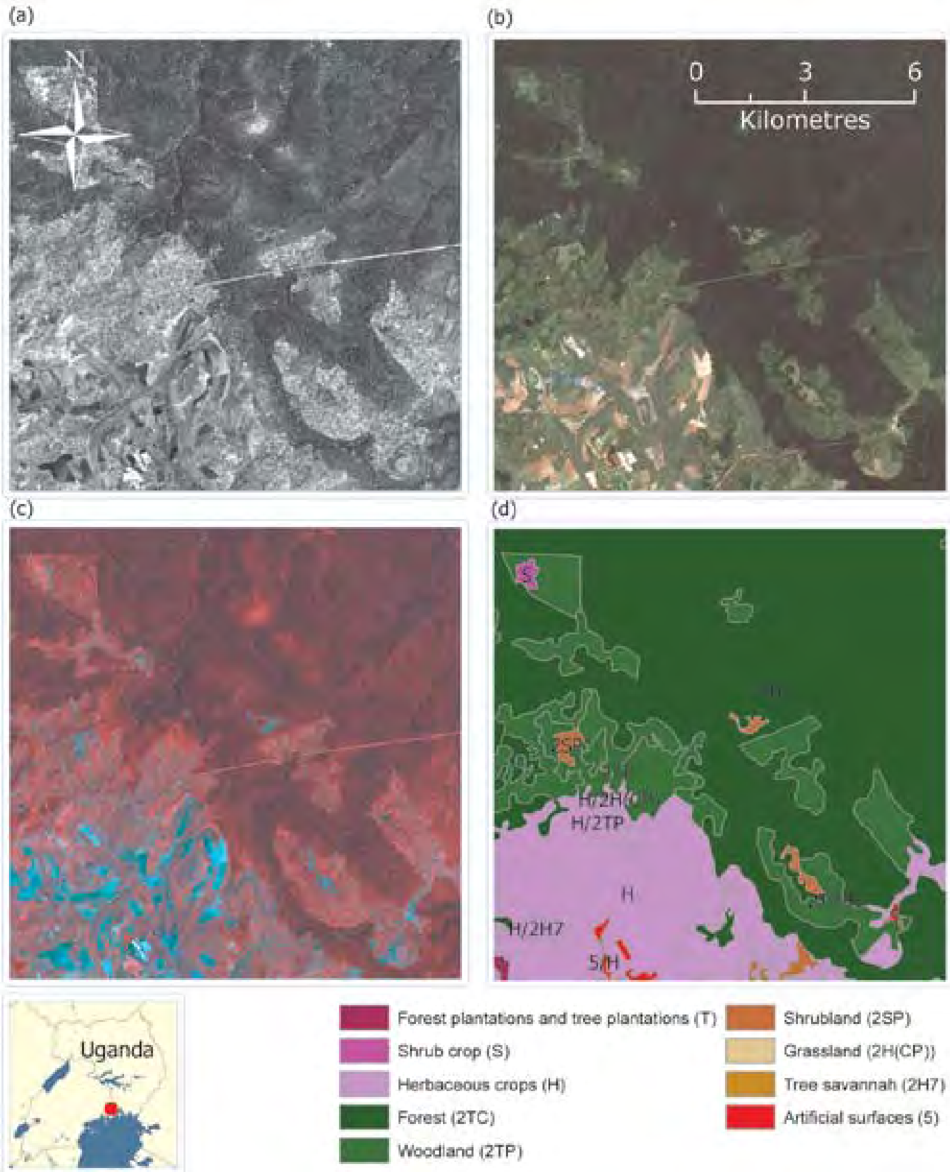
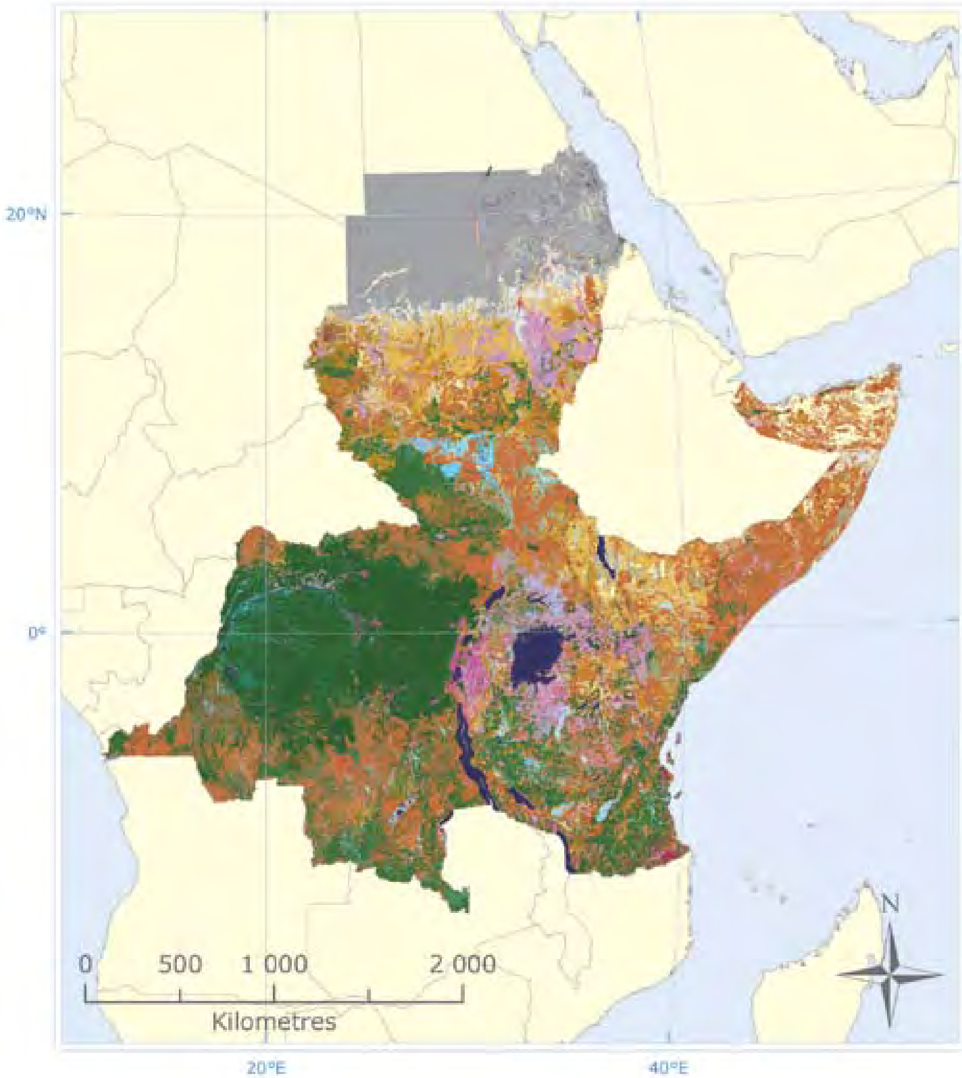
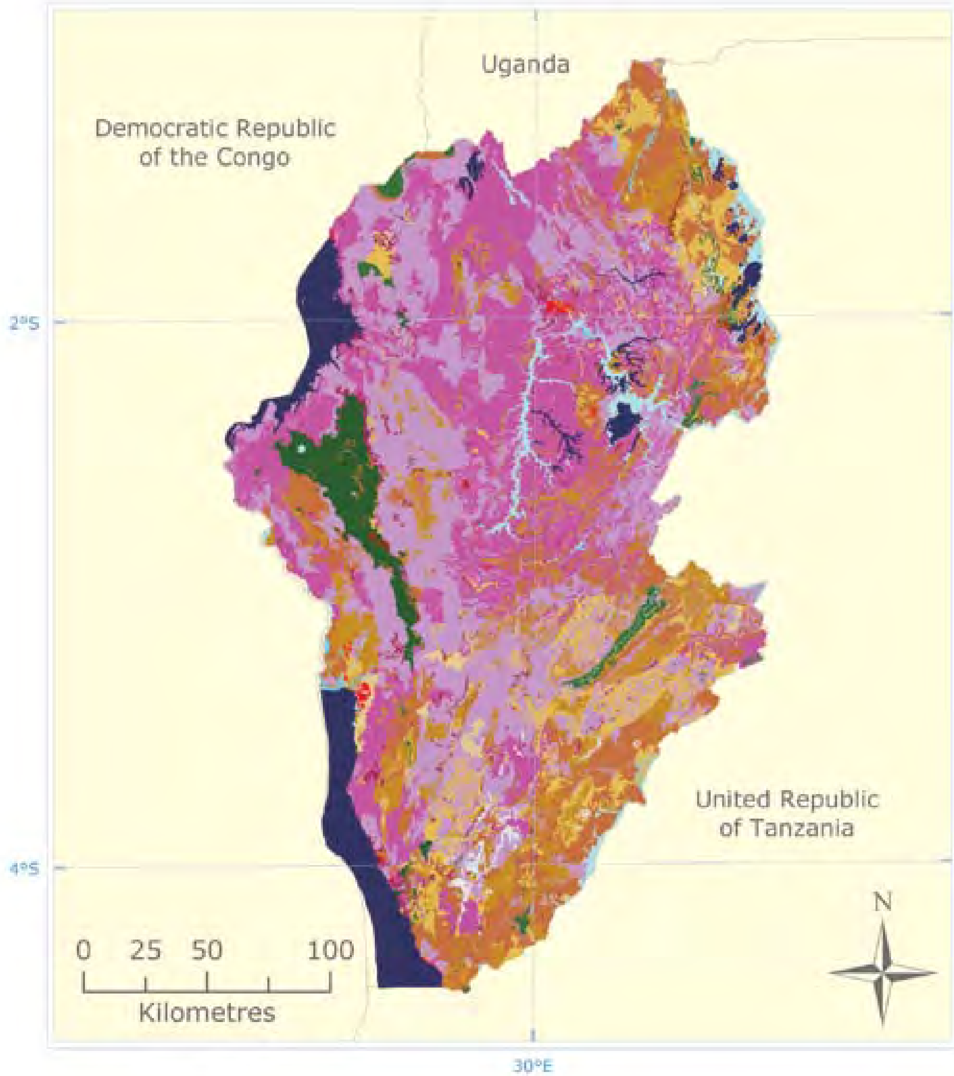


FIGURE 8
Africover land cover maps for tsetse and trypanosomiasis decision-making (the eight T&T affected countries mapped by the Africover project)



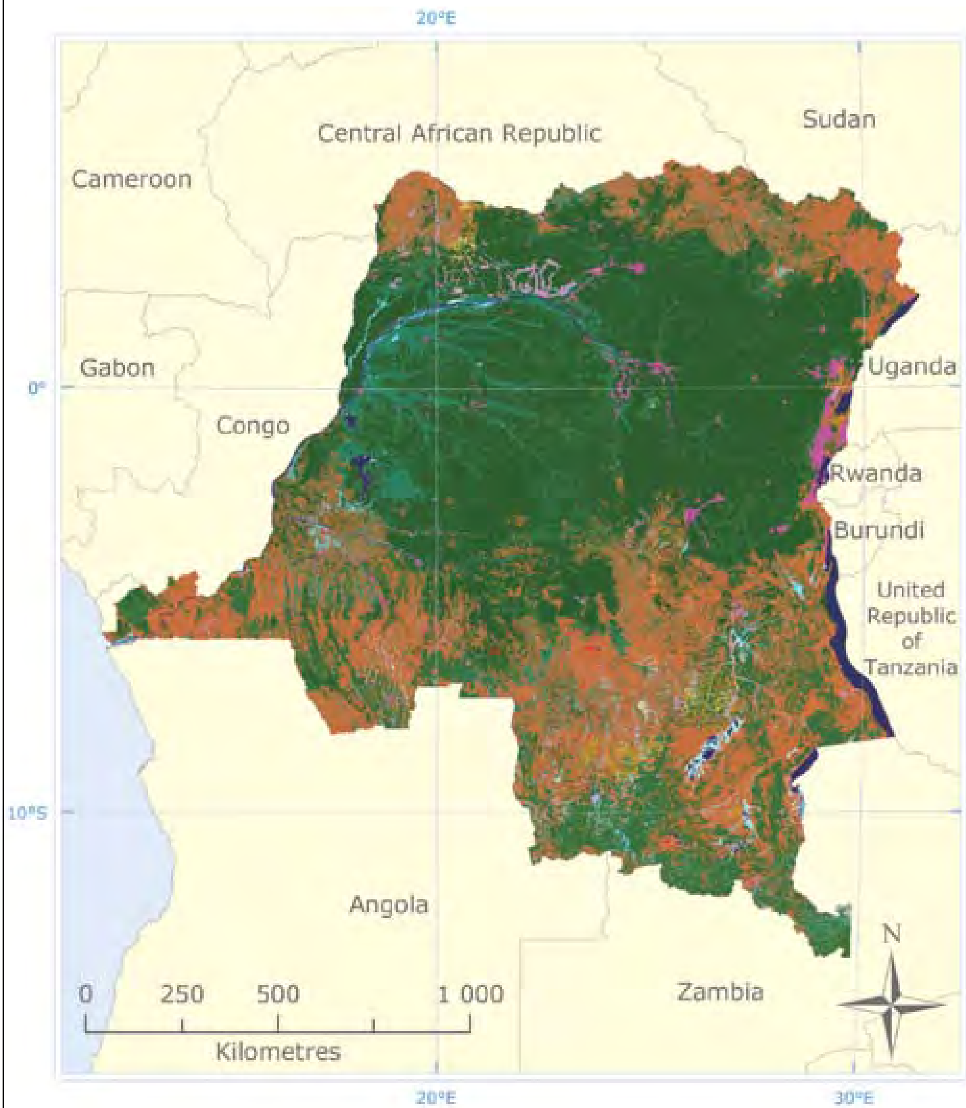
Note: The legend is in Table 7 (p. 21). The maps are available through FAO GeoNetwork (www.fao.org/geonetwork)

FIGURE 9
Land cover of Burundi and Rwanda for tsetse and trypanosomiasis decision-making



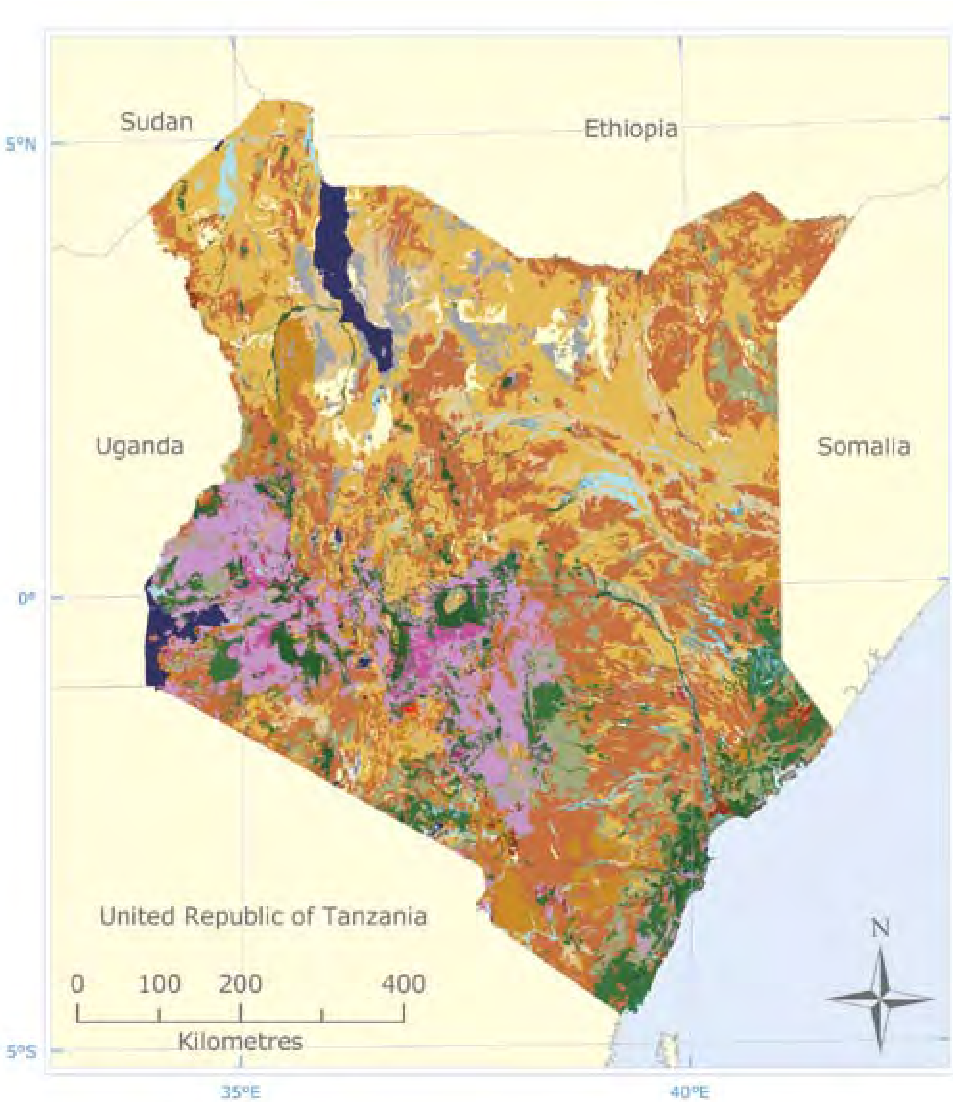
Note: The legend is in Table 7 (p. 21). The maps are available through FAO GeoNetwork (www.fao.org/geonetwork)

FIGURE 10
Land cover of Democratic Republic of the Congo for tsetse and trypanosomiasis decision-making



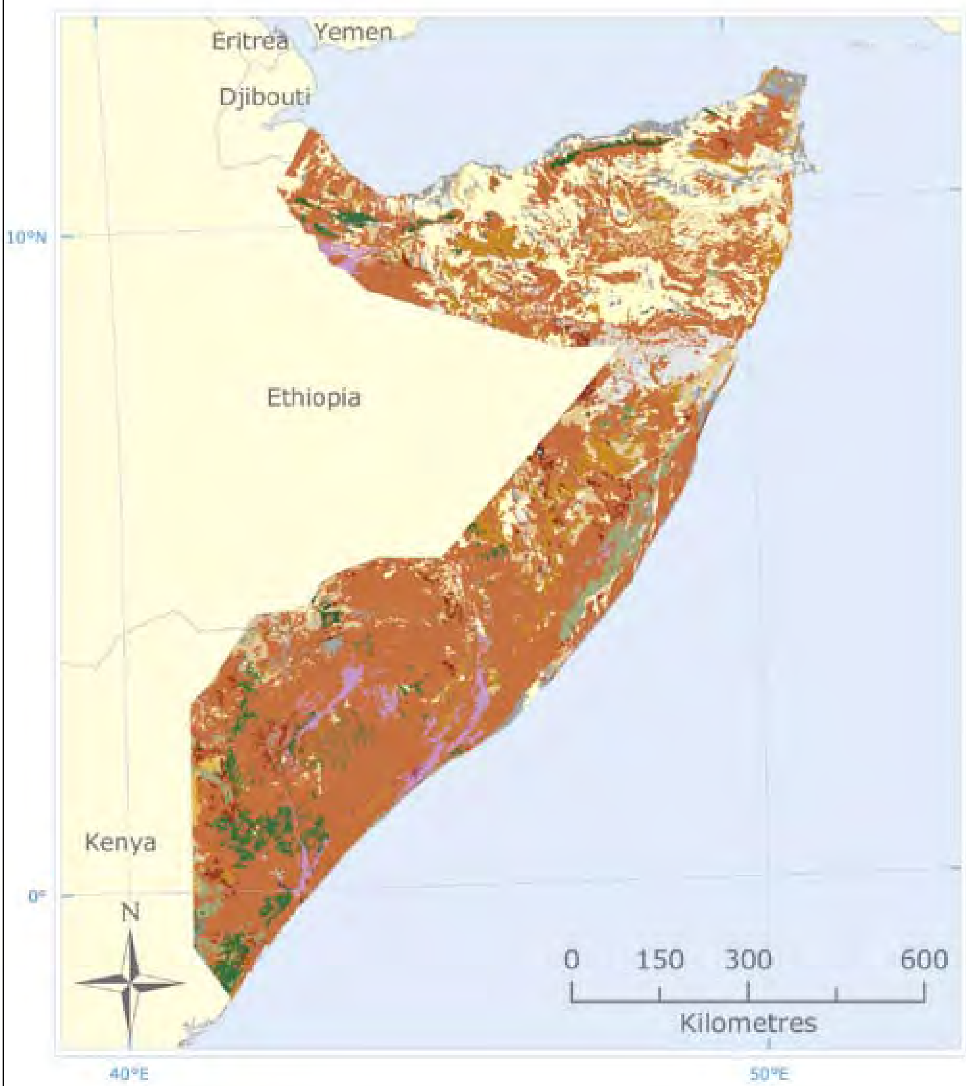
Note: The legend is in Table 7 (p. 21). The map is available through FAO GeoNetwork (www.fao.org/geonetwork)

FIGURE 11
Land cover of Kenya for tsetse and trypanosomiasis decision-making



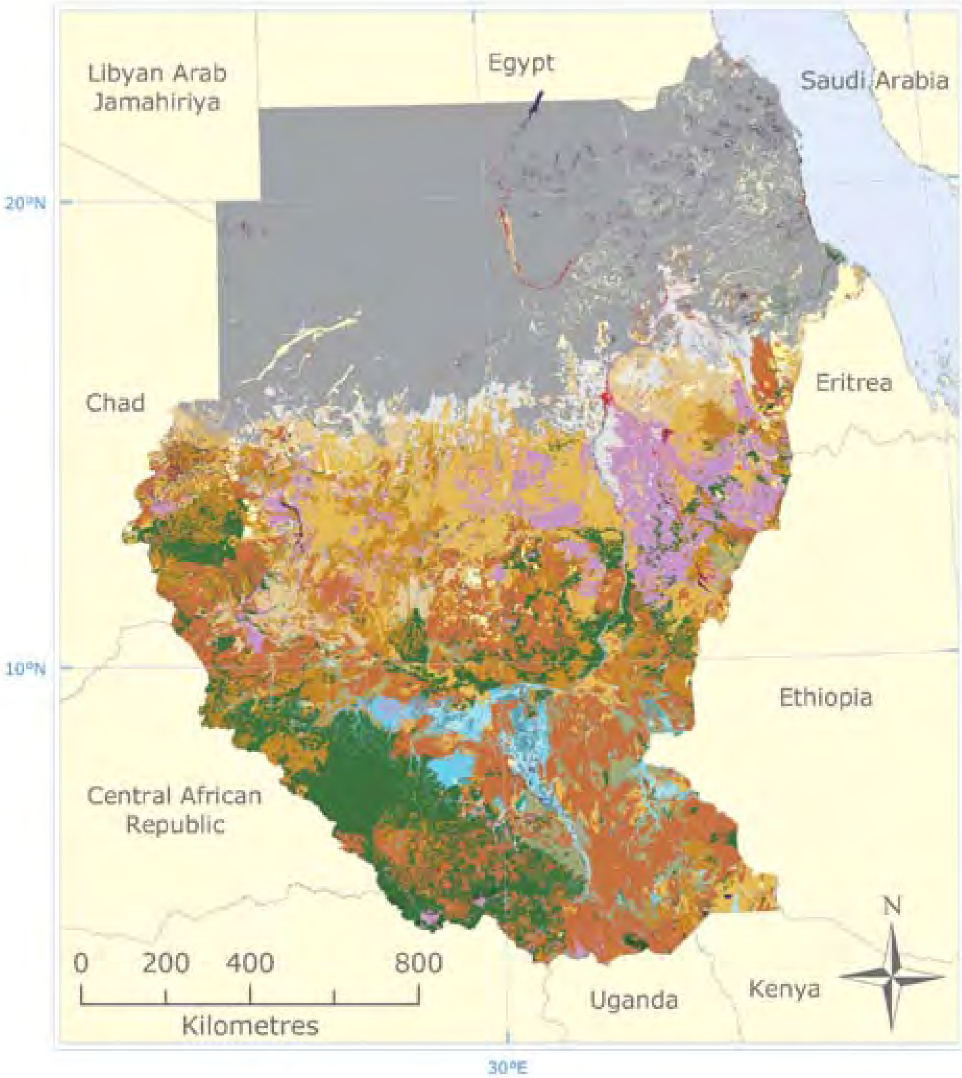
Note: The legend is in Table 7 (p. 21). The map is available through FAO GeoNetwork (www.fao.org/geonetwork)

FIGURE 12
Land cover of Somalia for tsetse and trypanosomiasis decision-making



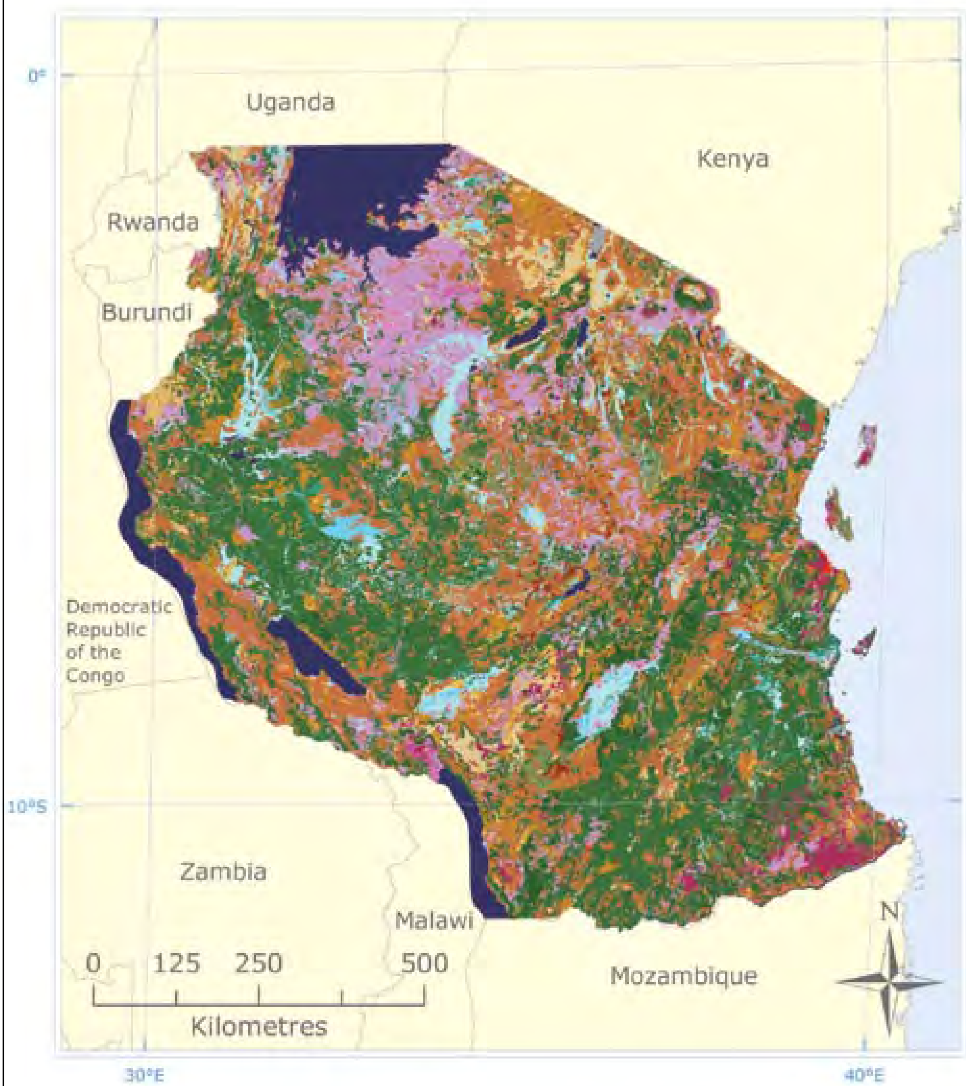
Note: The legend is in Table 7 (p. 21). The map is available through FAO GeoNetwork (www.fao.org/geonetwork)

FIGURE 13
Land cover of Sudan for tsetse and trypanosomiasis decision-making



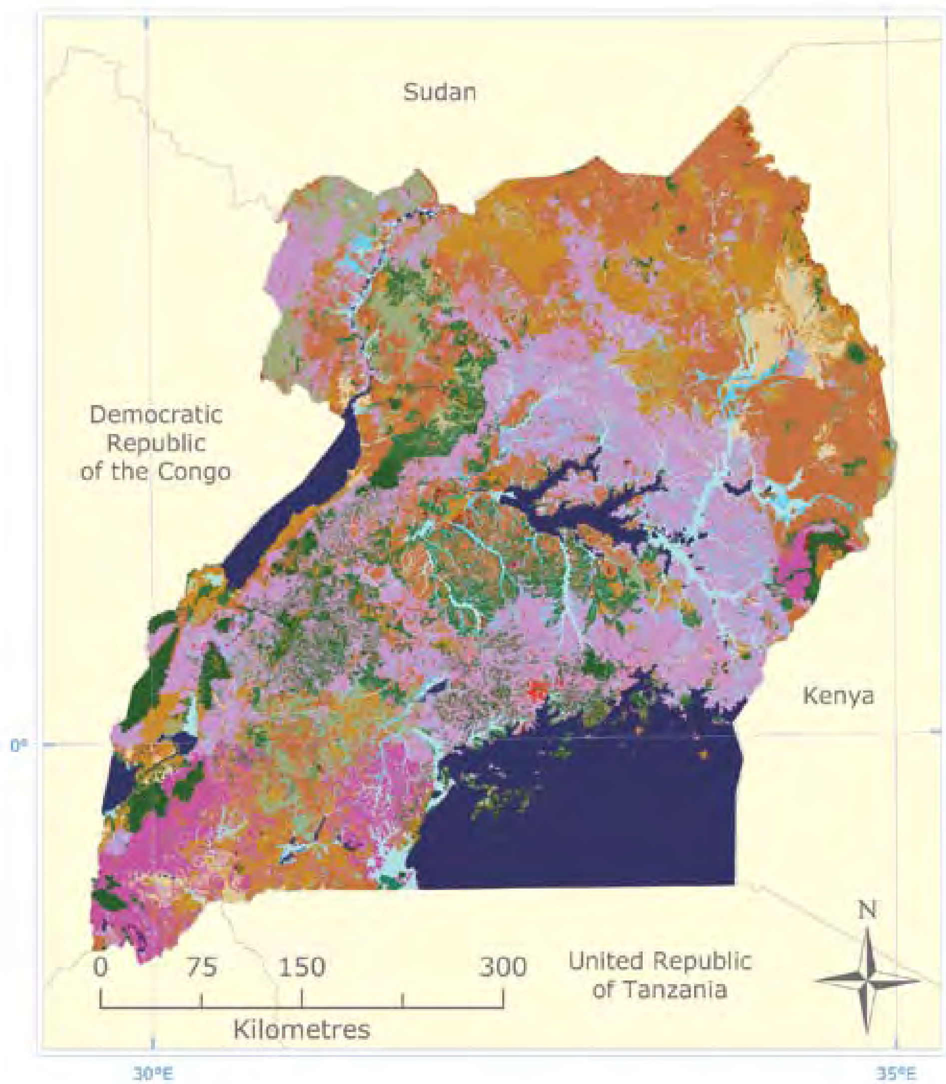
Note: The legend is in Table 7 (p. 21). The map is available through FAO GeoNetwork (www.fao.org/geonetwork)

FIGURE 14
Land cover of the United Republic of Tanzania for tsetse and trypanosomiasis decision-making



Note: The legend is in Table 7 (p. 21). The map is available through FAO GeoNetwork (www.fao.org/geonetwork)

FIGURE 15
Land cover of Uganda for tsetse and trypanosomiasis decision-making



Note: The legend is in Table 7 (p. 21). The map is available through FAO GeoNetwork (www.fao.org/geonetwork)

LAND COVER SUITABILITY FOR TSETSE FLIES: A DEDUCTIVE APPROACH

For the land cover classes defined in Table 7 (p. 21), it is possible to define a degree of suitability for the three tsetse groups. Because the goal of this exercise is to define a methodology applicable to all sub-Saharan countries, the ranking of the classes does not take into account the national or regional specificities. Even though it is derived from the aggregation of the land cover classes of the East African module of the Africover project, the proposed legend is general enough to encompass practically all possible land covers in the continent, at least as far as the vegetated areas are concerned. Furthermore, the definition of the classes is independent of the mapping scale, therefore the suitability classes were assigned without reference to the spatial resolution of the Africover maps from which they are derived.

The suitability for tsetse fly was assigned as a function of intrinsic features of the land cover class only, without *a priori* assumptions on the association or mosaic of various land cover patches. The underlying hypothesis was to consider an indefinite expanse of one single land cover type and to estimate its capability to support a fly population. The tsetse suitability for each land cover class is summarized in Table 8.

A complete account of the features of the land cover classes in Table 8 is beyond the scope of this paper; a full explanation of the LCCS methodology can be found in FAO (2005). However, it seems useful to clarify a few aspects that are probably not intuitive but which have important implications in the analysis of tsetse habitat requirements. One such aspect is the possible presence, in certain classes, of additional vegetation layers, which, not being always present and being, if present, always sparser that the main layer, have not been explicitly included in the name of the class. One example is the class ‘Thicket’. ‘Thicket’ as defined in Table 8 and with more details in Annex 1, does not always include a second layer of trees. At the same time, there is not a separate class named ‘thicket with emergent trees’, meaning that such a potential class has been aggregated with the general ‘Thicket’ (this is also apparent in the table of class aggregation for the Africover maps in Annex 3). Given this background, the suitability of the class ‘Thicket’ for tsetse flies was assigned considering that such additional vegetation layers could be present. Similar considerations apply to the classes ‘Closed’ and ‘Open woody vegetation’, ‘Shrubland’ (Figure 16, p. 34), ‘Woody vegetation on flooded land’, ‘Shrubs on flooded land’ and ‘Herbaceous vegetation on flooded land’.

In the case of terrestrial herbaceous vegetation it was decided not to discard all the information related to multiple layers and three distinct classes were defined: ‘Grassland’, ‘Shrub savannah’ and ‘Tree savannah’ (Figure 17, p. 34). In all three classes the main layer is herbaceous vegetation.

The fact that ‘Grassland’ as defined in our aggregation excludes the presence of additional vegetation layers (which are accounted for in the two savannahs) led to the estimated unsuitability of the class for tsetse flies.

Validation

Rigorous validation of the estimated suitability for tsetse of the land cover classes defined in Table 8 is hindered by a range of practical and conceptual difficulties. Foremost among the conceptual problems is the fact that land cover vegetation is only one component

TABLE 8
Land cover and tsetse suitability

LCC User Defined Label	Class name (User Defined Description)	Suitability for tsetse groups		
		fusca	*palpalis*	*morsitans*
T	Forest plantations and tree plantations	1	2	1
S	Shrub crop	1	1	1
H	Herbaceous crops	0	1	0
5UV	Vegetated urban areas	1	2	1
2TC	Forest	3	3	2
2TP	Woodland	1	2	3
2WC	Closed woody vegetation	1	2	2
2WP	Open woody vegetation	1	1	2
2SC	Thicket	1	1	2
2SP	Shrubland	0	1	2
2H7	Tree savannah	0	1	2
2H8	Shrub savannah	0	1	1
2H(CP)	Grassland	0	0	0
2TR	Sparse trees	0	0	1
2SR	Sparse shrubs	0	0	0
2HR	Sparse herbaceous vegetation	0	0	0
GZ-r	Fields Rice	0	0	0
4TC	Closed swamp	3	3	1
4TP	Open swamp	2	2	2
4W	Woody vegetation on flooded land	1	2	1
4S	Shrubs on flooded land	1	2	1
4H	Herbaceous vegetation on flooded land	0	1	0
5	Artificial surfaces	0	0	0
6	Bare soil	0	0	0
W	Water bodies	0	0	0
8SP	Snow	0	0	0

Tsetse suitability

3 - High
2 - Moderate
1 - Low
0 - Unsuitable

of potential tsetse habitat; favourable environmental conditions must include, *inter alia*, availability of hosts on which to feed and convenient climatic conditions. As a consequence, suitable vegetation can still represent an unsuitable habitat because of the lack of either of the above environmental conditions. A second difficulty is related to the challenge of defining classes of suitability valid for all sub-Saharan tsetse-infested countries; validation should be based on a number of sites capable of encompassing the enormous environmental heterogeneities in Africa. Another problem is related to the

FIGURE 16
Two possible structural configurations of the class 'Shrubland'

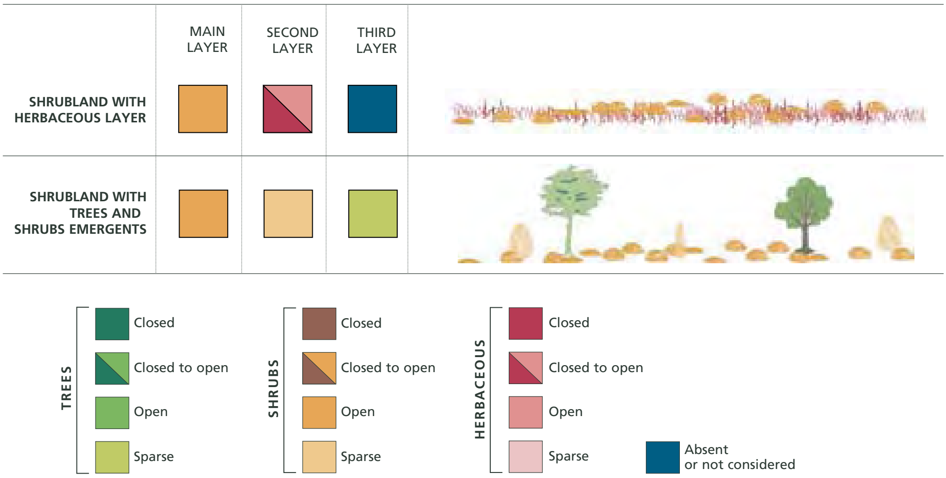
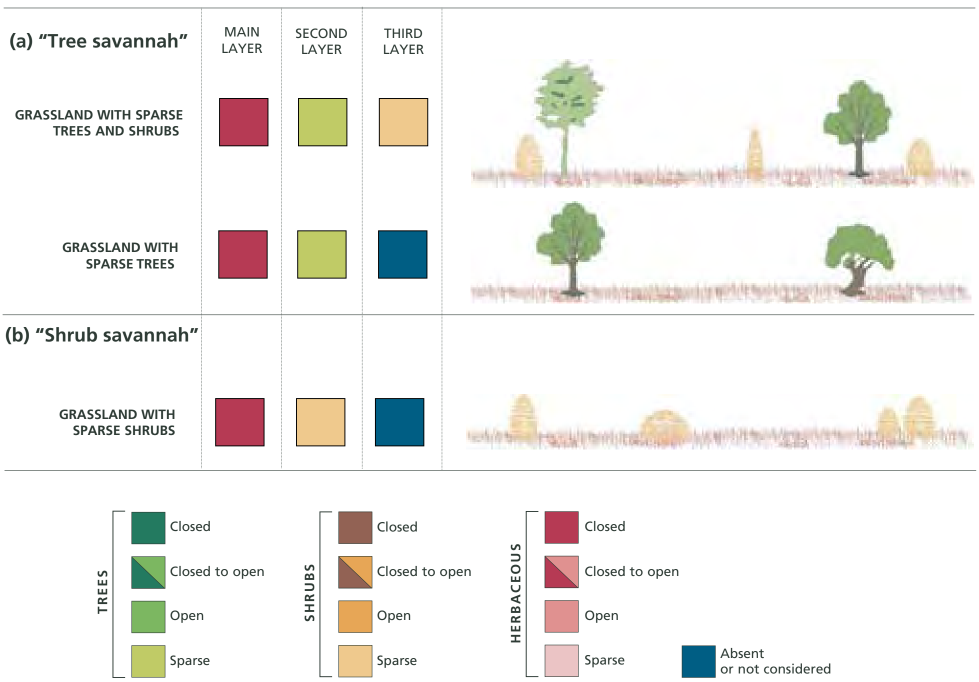


FIGURE 17
(a) 'Tree savannah' (with or without a third layer of shrubs) and (b) 'Shrub savannah' in the Land Cover Classification System



intra-group differences in habitat requirements; if the definitions of forest, riverine and savannah flies for the three groups *fusca*, *palpalis* and *morsitans* are commonly accepted, it is also true that the ecology and spatial distribution of the species within each group vary considerably (e.g. *G. longipennis*, belonging to the *fusca* group, and *G. tachinoides*, of the *palpalis* group, are found in more arid environments than the other species in the same groups). Another complicating factor is the dispersal of flies, some of which can easily travel hundreds of metres away from their resting and breeding sites for feeding; this implies that it is troublesome to link trap catches (i.e. apparent densities) to the vegetation in the immediate surroundings of the trap; trap catches are influenced by the vegetation mosaic at landscape level. In other words, it is almost impossible to define experimental conditions that comply with the hypothesis of 'indefinite expanse of one homogeneous land cover' on which the present evaluation is based. Furthermore, the opportunity to move in less shaded and less protected environments is heavily influenced by thermal and humidity gradients linked to seasonality.

The above considerations explain why very broad and qualitative suitability classes were used in the present paper. If updated and consistent entomological datasets were available, at least for one country or for a sufficiently large area, it would be possible to verify to what extent the suitability classes are capable of describing the situation on the ground.

Comparison between the inductive and deductive approaches at two spatial scales

In the previous section we discussed the reasons why it is difficult to envisage a rigorous validation of the estimated classes of suitability for tsetse (see Table 8, p. 33). Nevertheless it seems interesting to try to link the results of the study on a continental scale (described in Chapter 1) with the higher resolution land cover datasets presented in this chapter and available for some East African countries. The comparison helps to verify the validity of the estimates and demonstrate the limitations inherent in the overall approach.

In Chapter 1, the 26 classes of land cover defined in GLC2000 of Africa were ranked with respect to their suitability for tsetse on the basis of the percentages of suitable habitat within the land cover class; unfortunately these suitability values cannot be directly linked to the land cover classes used in the Africover maps, which in all comprise more than 500 classes. The issue is further compounded by the presence of Africover polygons with mixed encoding, characterized by up to three land cover classes. Even though the two datasets apply the same classification system, LCCS, the legends are different and the relationship between the classes in the two legends is not univocal.

An attempt was made to overcome the existing discrepancies in the legends through a statistical correlation between the classes of the two datasets. The original Africover maps were first thematically aggregated (see also the lookup table in Annex 3) to match the standardized legend for T&T and thus reduce the number of classes to 26, then the datasets were transformed from a vector into a grid format (grid spacing 0.00111 decimal degrees, about 120 metres at the equator) and overlaid with the GLC2000 of Africa (about 1.1 km resolution at the equator). For each class of Africover it was possible to determine the statistical relationship with the GCL2000 classes. As an example, in

Table 9 the results of the calculation for two Africover classes, i.e. 'Shrubland' and 'Shrubs on flooded land', are displayed. For the sake of clarity, only classes accounting for at least 1 percent were reported.

Table 9 gives a good picture of the degree of correspondence between GLC2000 and Africover. The case of 'Shrubland' is particularly relevant because it is the most widespread class in the eight T&T affected countries mapped by Africover, accounting for more than 20 percent of the total area. Overall, we can argue that for this class Africover and GLC2000 are sufficiently coherent, especially if we consider that 'Shrubland' in Africover for T&T encompasses a number of subclasses characterized by a second layer of emergent trees (see also Figure 16, p. 34).

TABLE 9
Correspondence between the classes 'Shrubland' and 'Shrubs on flooded land' of Africover and GLC2000

Africover for T&T Class name (User Defined Description)	Global land cover 2000 for Africa (%)	Class name
Shrubland	12.5	Deciduous woodland
	9.6	Deciduous shrubland with sparse trees
	9.5	Open grassland with sparse shrubs
	9.1	Croplands (>50 percent)
	8.9	Sparse grassland
	8.1	Mosaic forest / Savanna
	7.8	Open deciduous shrubland
	7.7	Closed deciduous forest (Miombo)
	6.7	Closed grassland
	6.2	Open grassland
	5.5	Croplands with open 0 vegetation
	2.1	Stony desert
	2.1	Closed evergreen lowland forest
	1.9	Bare rock
	1.2	Mosaic forest / Croplands
Shrubs on flooded land	24.8	Deciduous shrubland with sparse trees
	14.6	Deciduous woodland
	12.5	Croplands (>50 percent)
	9.2	Closed deciduous forest (Miombo)
	8.1	Swamp bushland and grassland
	8.1	Open deciduous shrubland
	3.4	Mosaic forest / Savanna
	3.3	Closed grassland
	3.3	Closed evergreen lowland forest
	3.0	Croplands with open woody vegetation
	2.9	Mosaic forest / Croplands
	2.8	Swamp forest
	2.5	Open grassland with sparse shrubs

An exhaustive discussion of the results of the comparison between Africover and GLC2000 is beyond the scope of this paper because it would call for a careful review of several technical issues related to the creation of the two land cover datasets. For our purposes it is sufficient to mention that, as for the two classes in the example, the analysis shows globally an acceptable match between the Africover maps for T&T decision-making and the GLC2000. More information on this point can be found in Torbick *et al.* (2005). It seems reasonable then to calculate the suitability for tsetse of the Africover classes as a function (weighted average) of the suitability of the GLC2000 classes that are statistically associated with them. For ease of comparison, the results of the calculation and the literature-based estimates are summarized in Table 10, Table 11 and Table 12.

Table 10 shows coherent and easy to interpret results for the *fusca* group. The two classes that are expected to provide the ideal habitat for flies of the *fusca* group on the basis of the available literature and expert opinion (estimated suitability) also got the top

TABLE 10
***Fusca* group: calculated and estimated suitability of standardized land cover classes**

LCC User Defined Label	Class name (User Defined Description)	Calculated suitability (%)	Estimated suitability (0–3)
2TC	Forest	82.0	3
4TC	Closed swamp	67.5	3
S	Shrub crop	40.2	1
4TP	Open swamp	16.8	2
2TP	Woodland	16.1	1
4S	Shrubs on flooded land	15.1	1
T	Forest plantations and tree plantations	13.0	1
5	Artificial surfaces	12.1	0
H	Herbaceous crops	11.0	0
5UV	Vegetated urban areas	9.5	1
4H	Herbaceous vegetation on flooded land	9.4	0
2WC	Closed woody vegetation	8.6	1
2SP	Shrubland	8.6	0
4W	Woody vegetation on flooded land	6.5	1
2WP	Open woody vegetation	6.2	1
2H7	Tree savannah	5.7	0
2SC	Thicket	5.4	1
GZ-r	Fields rice	5.0	0
W	Water bodies	3.4	0
2H8	Shrub savannah	2.6	0
2H(CP)	Grassland	2.1	0
2TR	Sparse trees	1.4	0
8SP	Snow	0.8	0
2SR	Sparse shrubs	0.5	0
2HR	Sparse herbaceous vegetation	0.3	0
6	Bare soil	0.1	0

TABLE 11
***Palpalis* group: calculated and estimated suitability of standardized land cover classes**

LCC User Defined Label	Class name (User Defined Description)	Calculated suitability (%)	Estimated suitability (0–3)
2TC	Forest	86.0	3
4TC	Closed swamp	72.2	3
S	Shrub crop	48.6	1
2TP	Woodland	34.6	2
4S	Shrubs on flooded land	33.0	2
T	Forest plantations and tree plantations	30.9	2
4TP	Open swamp	30.4	2
2WC	Closed woody vegetation	27.7	2
4H	Herbaceous vegetation on flooded land	21.7	1
H	Herbaceous crops	20.2	1
5	Artificial surfaces	20.2	0
2SP	Shrubland	19.9	1
4W	Woody vegetation on flooded land	19.1	2
2WP	Open woody vegetation	18.8	1
2H7	Tree savannah	17.6	1
5UV	Vegetated urban areas	16.0	2
GZ-r	Fields rice	12.3	0
2SC	Thicket	10.7	1
2TR	Sparse trees	6.3	0
2H8	Shrub savannah	5.7	1
2H(CP)	Grassland	4.7	0
W	Water bodies	4.2	0
2SR	Sparse shrubs	0.8	0
2HR	Sparse herbaceous vegetation	0.2	0
6	Bare soil	0.2	0
8SP	Snow	0.1	0

scores in the calculation. The thresholds for the ranking of the calculated suitability are the same used in Chapter 1 for GLC2000 classes (see Table 2, p. 7): 5 percent, 25 percent and 50 percent. For 73 percent of the classes the calculation confirms the literature-based estimates and the seven non-matching classes only differ by one class. Nevertheless, a closer look at the figures reveals why the calculations proposed in this section, cannot be used to validate, or in the place of, the estimated suitability. For the class 'Artificial surfaces' the indicator provides a non-null value higher than 5 percent that we interpret as 'low suitability' for tsetse flies of the *fusca* group. Yet we know that non-vegetated areas are not capable of sustaining fly populations. The reason for this discrepancy can be traced back to the resolution of the tsetse habitat maps used to assess the suitability of the GLC2000; the 5 km resolution of these maps is too coarse to depict the presence of most artificial areas in Africa (among which are many urban areas). As a consequence the 'Cities' of GLC2000 are often wrongly considered a suitable habitat for tsetse. This

TABLE 12
***Morsitans* group: calculated and estimated suitability of standardized land cover classes**

LCC User Defined Label	Class name (User Defined Description)	Calculated suitability (%)	Estimated suitability (0–3)
4W	Woody vegetation on flooded land	30.4	1
4S	Shrubs on flooded land	28.0	1
2TP	Woodland	23.4	3
4H	Herbaceous vegetation on flooded land	23.3	0
2WC	Closed woody vegetation	20.8	2
2WP	Open woody vegetation	20.8	2
T	Forest plantations and tree plantations	19.0	1
4TP	Open swamp	18.5	2
2H7	Tree savannah	18.3	2
5UV	Vegetated urban areas	16.6	1
2SP	Shrubland	16.4	2
H	Herbaceous crops	16.1	0
S	Shrub crop	15.8	1
GZ-r	Fields rice	15.2	0
5	Artificial surfaces	13.2	0
2SC	Thicket	8.2	2
2TR	Sparse trees	7.4	1
2TC	Forest	7.4	2
2H8	Shrub savannah	6.6	1
4TC	Closed swamp	6.5	1
2H(CP)	Grassland	5.6	0
W	Water bodies	1.7	0
2SR	Sparse shrubs	1.2	0
8SP	Snow	0.5	0
2HR	Sparse herbaceous vegetation	0.3	0
6	Bare soil	0.2	0

kind of drawback is particularly evident in less represented classes, but it also affects the overall accuracy of the calculations.

Substantial agreement between calculated and estimated suitability was also demonstrated for the *palpalis* group (Table 11). In this case, a slightly lower number of classes (namely six) differ, but still by no more than one class of suitability. Nevertheless, a different type of bias becomes clearer in Table 11. If we consider the class 'Fields rice' we discover that it has no direct equivalent in the GLC2000 legend; almost half of the 'Fields rice' of the Africover maps are classified in GLC2000 as a more general 'Cropland' and the calculated suitability reflects this association. This case exemplifies the nature and magnitude of the errors induced by the different legends of Africover and GLC2000.

We already discussed the fuzzier relationship between the habitat of the *morsitans* group and land cover; Table 12 confirms the more complex interpretation of the results related to the subgenus *morsitans*. For more than half of the classes the two indices differ; for the Africover class 'Woodland', considered the most suitable habitat for this group of flies, the difference is of two classes of suitability. Furthermore the two classes that score the highest values of the calculated suitability all belong to the group of 'Aquatic or regularly flooded vegetation', strictly linked to hydrological network (see also Figure 23, p. 51). If it is true that during the dry seasons the riparian vegetation is a very favourable environment for flies of the *morsitans* group, it is not traditionally considered their typical habitat, being largely surpassed by open woodland and woodland savannah. The rather homogeneous figures of the calculated suitability in Table 12 seem to confirm that *morsitans* group flies are indeed more versatile, dispersive and invasive than those flies that remain in the forest and riparian vegetation.