# THE KAGERA TRANSBOUNDARY AGRO-ECOSYSTEM PROGRAMME (TAMP): GIS DIAGNOSTIC STUDY (UGANDA COMPONENT)

**PREPARED BY MUIENR GEO-GRAPHIC SERVICES (U) LIMITED FOR FAO-TAMP**


**TECHNICAL REPORT (final draft)**

## 1.0 UGANDA: THE KAGERA RIVER BASIN – GENERAL INTRODUCTION

The Kagera River Basin provides a major catchment (approximately 10% of the water of the downstream Nile Basin and 75% of the up stream of the Lake Victoria Basin). Water inflow contributed to Lake Victoria Basin by the Kagera Basin is the largest inflow and is estimated at 7.5 $km^3$ per year, representing some 8-10% of the Nile drainage water. The river basin originates in the highlands of Rwanda and Burundi and flows as the Kagera River along the border between Rwanda and Tanzania and later forms the border between Tanzania and Uganda. The Kagera River Basin constitutes a total area of 59,800 $km^2$. In Uganda, the Kagera River Basin covers a total area of 5,980 $km^2$, representing 10% of the total areas of the Kagera Basin). The Kagera River Basin traverses six districts of Uganda (Kabale, Ntungamo, Kabingo, Kiruhura and Rakai (Figure 1).

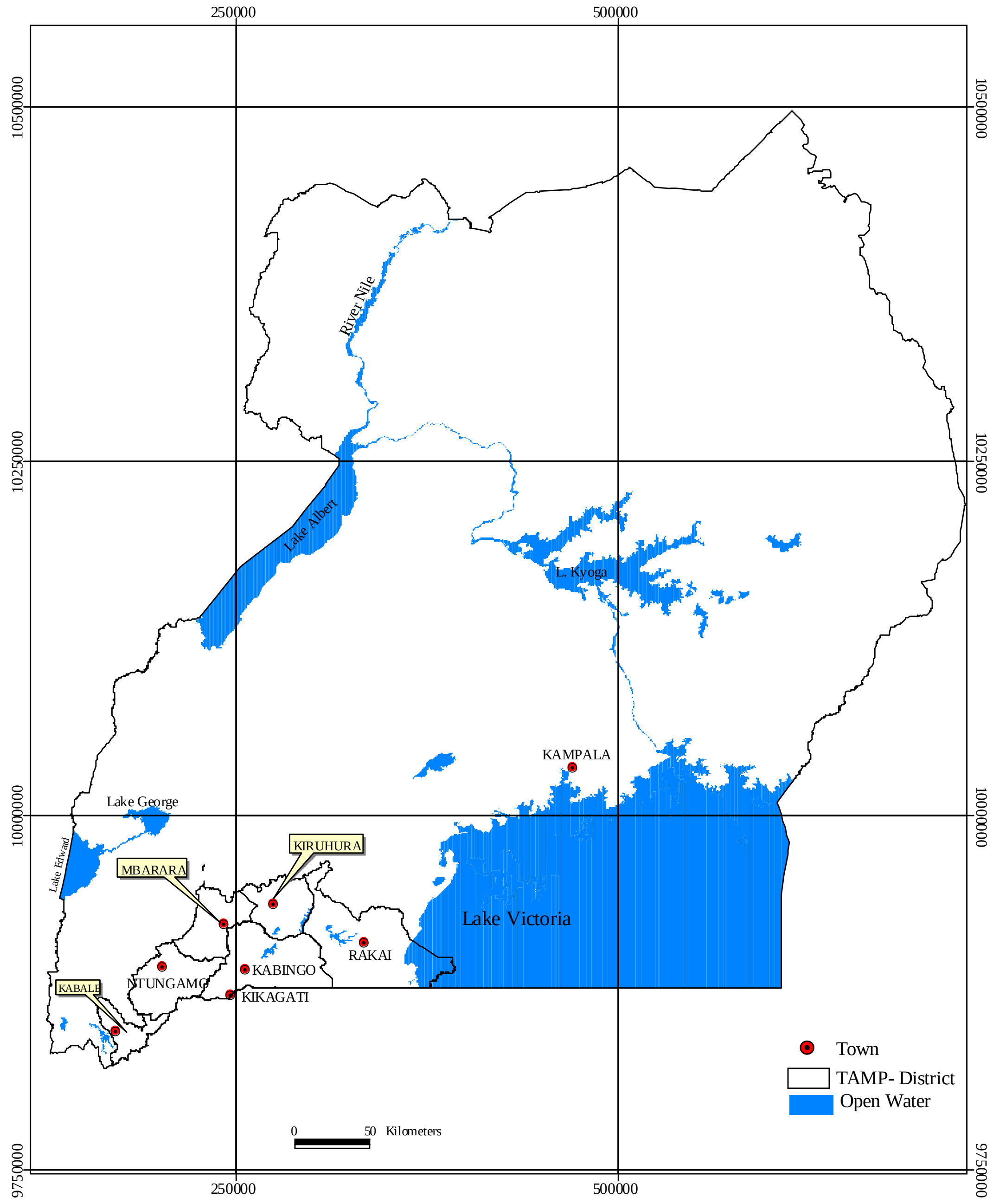



**Figure 1. Uganda: districts that contribute to the Kagera River Basin in Uganda**

Approximately 34% (i.e. 5,980 out of 17,743 $km^2$) of the surface area of the six districts of Uganda form part of the Kagera River Basin. While the amount of surface area contributed by each of the six districts is not yet calculated, the areal extent of each district is presented in Table 1. Included in the same table is the extent of the amount of land under open water, forest reserves and national parks for each district. Based on the Figures presented in Table 1, approximately 90% of the six districts (contributing to the Kagera River Basin) is neither under conservation (forest reserves and national parks) or open water bodies, implying that most of the basin (in Uganda) is potentially under uncontrolled human degradation influences.

**Table 1. The Kagera River Basin Districts of Uganda: district, forest reserves, national parks and open water extents.**

| District | Total Area | Forest Reserve | National Park | Open water |
|---|---|---|---|---|
| Kabale | 1,730 | 47 | 57 | 51 |
| Kabingo | 2,651 | 28 | | 38 |
| Kiruhura | 4,603 | 0.5 | 369 | 40 |
| Mbarara | 1,794 | 58 | | 1 |
| Ntungamo | 2,056 | 61 | | 4 |
| Rakai | 4,909 | 388 | | 751 |
| **Grand Total** | **17,743** | **582** | **427** | **884** |

## 2.0 GIS DIAGNOSTIC STUDY: GENERAL APPROACH

The overall purpose of the Kagera River Basin GIS diagnostic study (Uganda Chapter) was to establish a GIS database relevant to the TAMP activities; and conduct initial analyses on key indicators of land degradation. Based on the overall purpose of the study, two major activities were identified by MUIENR Geographic Services as key to the completion of the study:

a) Preparation of a GIS digital database from existing datasets achieved by different organisations; and
b) To use the prepared GIS database to conduct initial analysis in order to generate information for guiding FAO/GEF team prepare a sound proposal under the Proposal Development Fund phase.

From the above two activities, there were two major outputs: a CD containing the prepared GIS database and this report detailing the study approach and major analytical outputs. In order to include some of the prepared maps (of the Kagera River Basin of Uganda) in this report, a decision was made to prepare the report on A3-size paper.The details of the study approach are presented in the following subsections.

### 2.1 Delineation of the Kagera River Basin boundary for Uganda

In the present study, the Kagera River Basin was not delineated because of a lack of an appropriate digital elevation. The most appropriate data (contours mapped at a scale of 1:50,000) with a vertical resolution of about 16.4 m) were found to be unusable because it was characterised by wrong assignments of altitude values to individual contours. An attempt to derive a digital elevation model (DEM) from the erroneous contours yielded unusable DEM for the Ugandan Kagera River Basin. The only option was to derive the DEM, using TNTmips Version 7.0, of the Ugandan Kagera River Basin from a global DEM data (horizontal resolution of 90 m). The coarse resolution DEM was used to derive the Kagera River Basin. The derived river basin resembles of that of Uganda's Lake Victoria rather than that of the Kagera River Basin (Figure 2). This is because the vertical resolution of the the global DEM data was not good enough to sufficiently separate the the two basins (Lake Victoria and Kagera Basins). However, since the Kagera River Basin is a subset of the Lake Victoria Basin in the area of interest, the boundary of the former was used as a basis of the geographic extent of the present study, pending a better DEM that can allow the delineation of the Kagera River Basin. Consequently, all the maps presented in this report are delineated based on the Lake Victoria Basin of the study area (Figure 2).

The Lake Victoria Basin boundary (dark boundary ) in southern Uganda. The Kagera river basin is smaller than the entire Lake Victoria Basin in the region. However, the Kagera river basin (in Uganda) is a subset of the Lake Victoria Basin shown in the map below (Figure 2). As indicated on the map legend below, the hydrological variables (major and minor flow paths) were modeled, together with the basin boundary, using TNTmips software and the DEM.  The major follow paths can be assumed to have been modeled accurately because they flow in or out of the major existing lakes (superimposed on the modeled hydrological variables) on the map below.

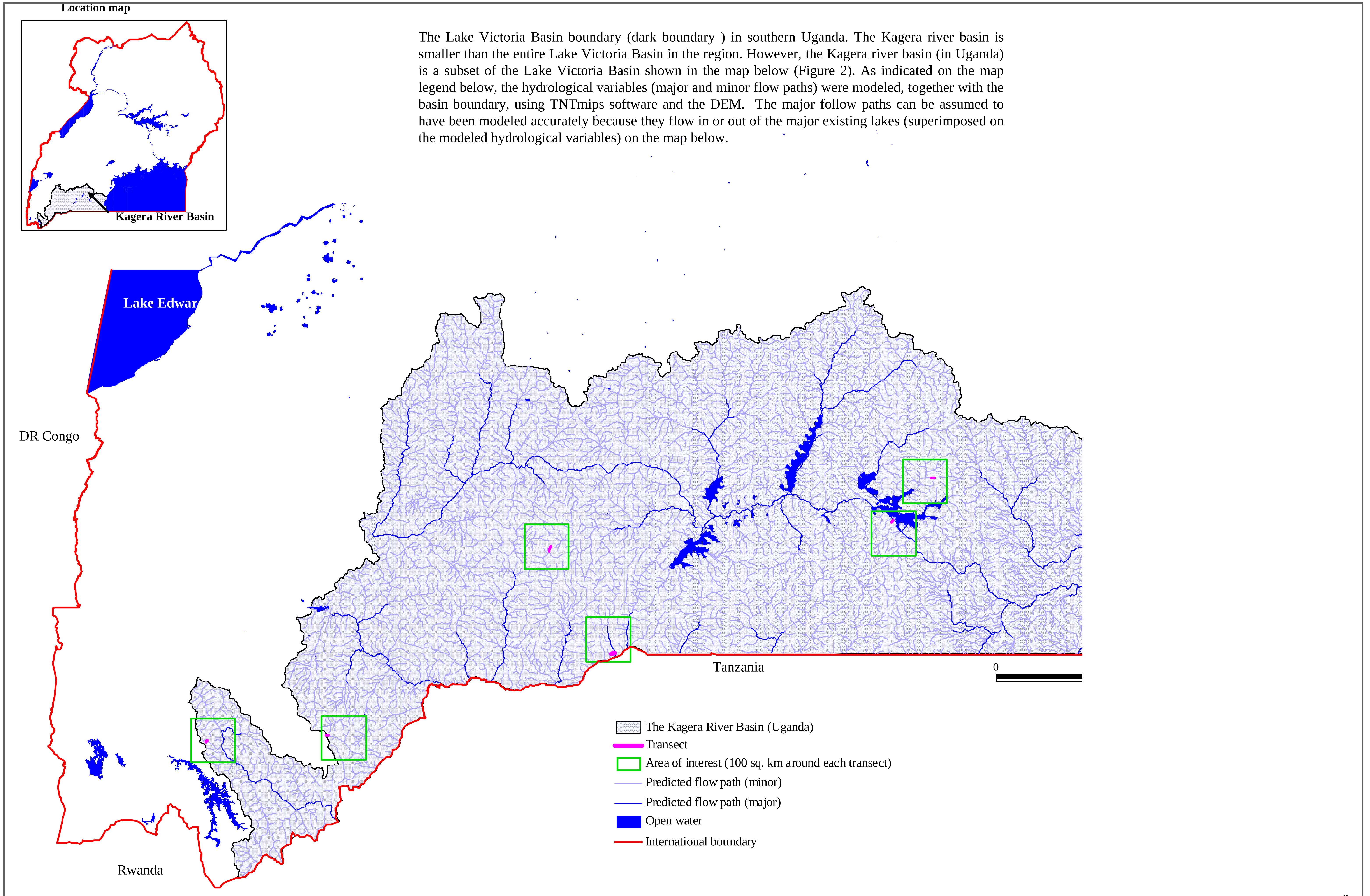



**Figure 2. Part of Lake Victoria Basin to which the Kagera River Basin is a subset.**

### 2.2 Biophysical and socio-economic characterisation – GIS database

As pointed out above, biophysical and socio-economic characterisation of the watershed basin depicted in Figure 2 was carried mostly based on existing GIS digital data layers. The used data would have been produced by different agencies (both governmental and non-governmental) at different times, cartographic scales and in some case different map projection. These data have been used as a basis of extracting the GIS database for the watershed shown in Figure 2.

The map layers extracted for the study area were all transformed to a common map project, UTM. The GIS database was prepared in Arc View format (shape files) for easy accessibility by the end-users. A CD of the GIS database and a metadata report have been prepared and is part of the output for the study. The key findings of biophysical and socio-economic characterisation, based on the existing datasets, are presented in Section 3.0.

### 2.3 Data analysis

The biophysical and socio-economic database (see Section 3.0) was analysed to yield useful information for the project. The analyses ranged from simple data summaries and statistics to change analyses of population and land use/cover. The specific techniques used during change analysis are explained under each type of analysis carried out. The spatial analysis was possible because all the maps were transformed to the same map projection parameters, UTM.

### 2.4 Fieldwork

Fieldwork was conducted in two exceptional circumstances. The first instance when fieldwork was conducted was to map six transects, using a GPS, during which fieldwork was conducted by the TAMP-Ugandan team.During the fieldwork, both land utilisation and land use types were described along the entire length of each of the six transects. The second instance when fieldwork was conducted was to collect 'ground-truth' for determining the accuracy of Africover map of Uganda. Ground truthing was important because there are some indications that land cover maps derived from low/coarse resolution satellite imagery may be characterised by significant errors in savanna and small-scale farmed ecosystems of Uganda (Figure 3).

**(a)**

**(b)**

**Figure 3. Typical savanna vegetation (a) and small-scale farmed (b) ecosystems in the Kagera River Basin of Uganda.**

## 3.0 STUDY FINDINGS

The study findings are present beginning with the biophysical and through the socio-economic variables characteristic of the watershed shown in Figure 2. In a case where the spatial data would have been analysed to generate information, such information is presented immediately after the variables have been presented. The last part of the study findings to presented in this report relate to work conducted along and around each of the six transects described by the entire TAMP team.

### 3.1 Landforms

The watershed of interest (Figure 2) is constituted of five major landforms. The most low-lying and almost flat lacustrine landform is adjacent to Lake Victoria (1,000 – 1,250 m above see level). This lacustrine landform is characterised by extensive wetlands, seasonal and permanent, swamp forests, and a variety of mixtures of grasslands/shrubs (Figure 4). The lacustrine type of landform is characterised by sandy soils given its proximity to Lake Victoria (Figure 5). The use of such sandy soils for arable farming is limited and hence the reason why lacustrine landform, in the watershed of interest, is still covered by natural vegetation (Figure 4). Indeed, the only farmed part of this region (the lacustrine landform) are few raised hills (1,250 – 1,500 m).

**Figure 4. Extensive natural vegetation and patches of sandy soils characterize the lacustrine landform (1,000 – 1,250 m) That is adjacent to Lake Victoria (dark green colour in Figure 5).**

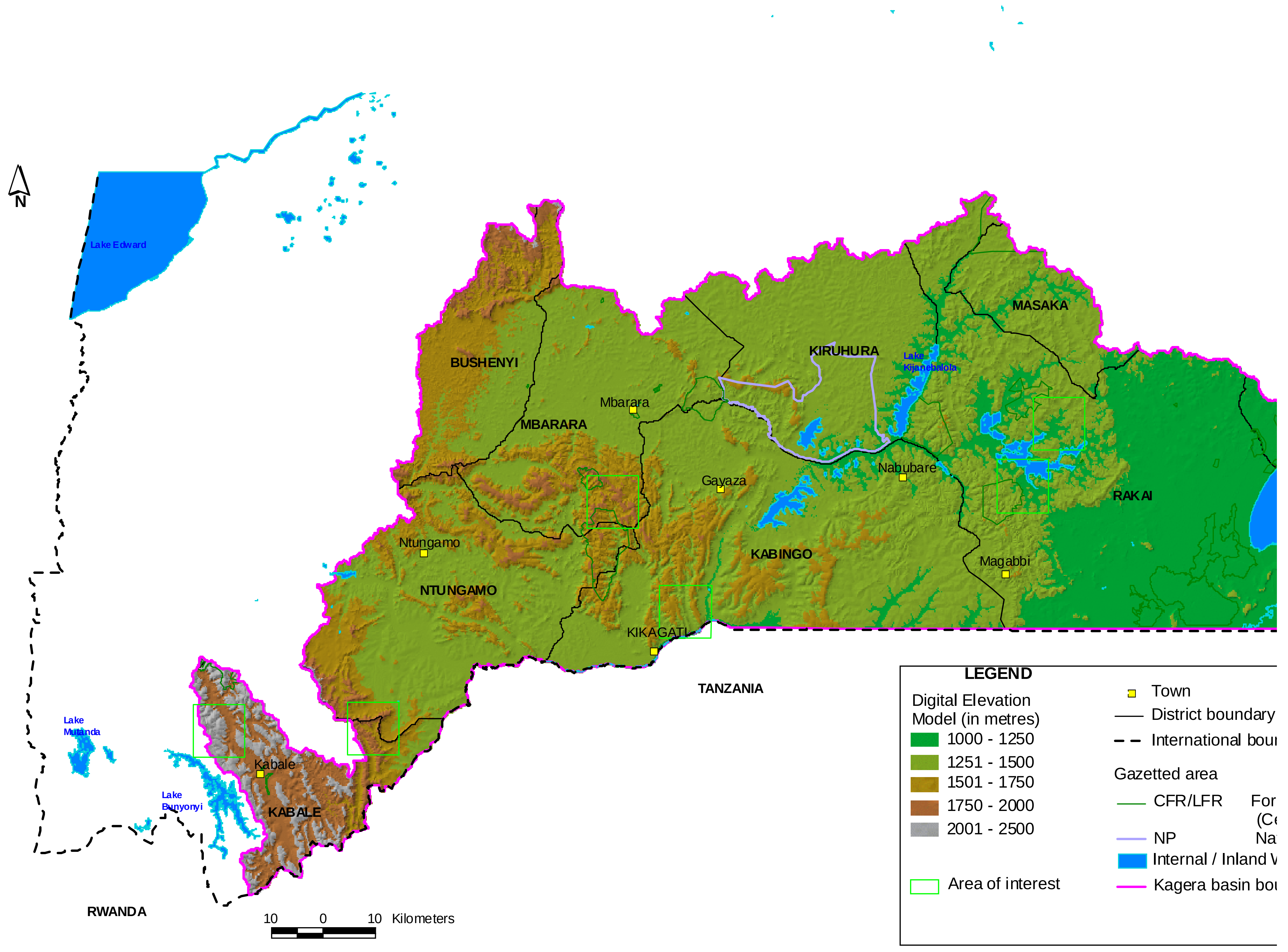



Figure 5. Landforms within the Lake Victoria/Kagera Basin.

Given the fact that the lacustrine landform, adjacent to Lake Victoria, is mostly non-arable land due to very sandy soils, the extensive wetlands and grasslands have become grazing areas by large numbers of pastoralists who seasonally migrate from the drier cattle corridors of Uganda, Rwanda and Tanzania. Indeed recent studies in Sango Bay (part of the lacustrine landform) indicate that grazing is most likely to degrade the extensive natural vegetation depicted in Figure 6.

**Figure 6. Extensive natural grassland on sandy soils of the lacustrine landform that is extensively grazed by pastoralists in The Kagera/Lake Victoria Basins.**

Probably the most extensive landform characteristic of the Lake Victoria/Kagera Basin is the undulating plateau raising from 1250 – 1,750 m above sea level and extending westwards from the lacustrine landform to the big hills of Kabale District (Figure 5). A significant part of the undulating landform is characterised by insufficient soil moisture, providing extensive rangelands (referred to as the animal corridor). However, given the dwindling arable land with enough soil moisture, the animal corridor that dominates this undulating landform (1,250 – 1,750 m) is being converted into farmlands (Figure 7).

While most of the undulating landform has limited soil moisture for a significant part of the year, the region is characterised by extensive wetlands around major water bodies suchas Lakes Mburo and Kijjanibalora. Of recent, about 6 years ago according to the local people, a new small lake called Nyamurunga (not yet mapped) was formed from an existing wetland found in the undulating landform of Kabingo District (Figure 8). Note the nature of the savanna vegetation that is an indicator of limited soil moisture for a significant part of each calendar year.

**Figure 7. The undulating landform is the most extensive landform within the Lake Victoria/Kagera Basin. Most of it is characterised by insufficient soil moisture and hence used as rangeland and of recent subsistence farming.**

**Figure 8. Part of the recent lake formed from a wetland located in Kabingo District (undulating landform).**

The third category of the landforms is hilly to very hilly in nature and ranges from 1,750 – 2,500 m above sea level (Figure 5). The hilly landforms (1,750 – 2,000 m above sea level) interrupt the undulating landforms (in some parts of Kabingo, Mbarara and Ntungamo Districts) as one moves west of Lake Victoria before reaching very hilly landforms of Kabale District (1,750 – 2,500 m above sea level). The two sub types of the hilly/very hilly landforms are characterised by sufficient soil moisture. Hence, the landform provides arable land especially in valleys and lower/mid slopes (Figures 9 and 10). The upper parts of the slopes are used as grazing lands (Figure 9), and to a large extent are planted with *Eucalyptus* woodlots (Figure 10). whether the soil moisture is limiting, the vegetation characteristic of this landform is used for cattle keeping.

**Figure 9. Extensive banana plantations in the valleys of the hilly landforms of Mbarara District.**

**Figure 10. Settlements and cultivation in the valleys and lower slopes of the very hilly landforms in Kabale District.**

**3.2 Soils**

Owing to the relatively recent uplifts (at a geological scale) that yielded the landforms described above, combined with other soil forming factors (climatic conditions, nature of the rocks, vegetation, anthropogenic factors), one finds a variety of soil types within the Lake Victoria/Kagera Basin of Uganda. The lacustrine landforms provide a basis for the sandy soils account 33%, while the loams and clays account for 40% and 27% respectively (Figure 11). In terms of areal coverage and spatial extent of the major soil types, the reader is referred to Table 2 and Figure 12.

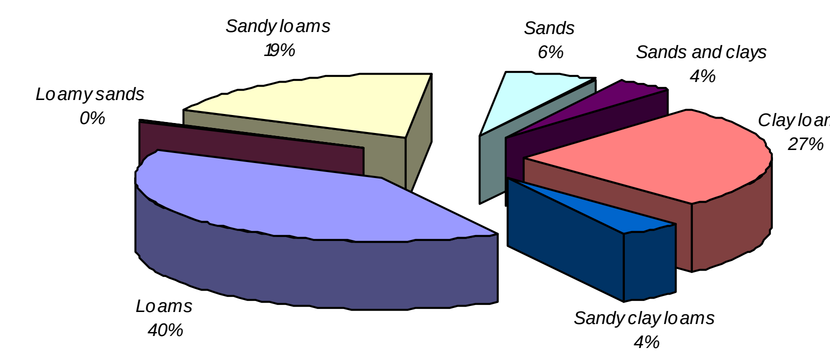



**Figure 11. Major soil types in the Lake Victoria/Kagera Basin, Uganda.**

**Table 2. The areal extent of soils of the Lake Victoria/Kagera Basin, Uganda.**

| Map code | Soil type | Area (km$^2$) | Percentage |
|---|---|---|---|
| 1 | Loams | 5,073 | 39.7 |
| 2 | Loamy sands | 38 | 0.3 |
| 3 | Sandy loams | 2,466 | 19.3 |
| 4 | Sands | 783 | 6.1 |
| 5 | Sands and clays | 487 | 3.8 |
| 6 | Clay loams | 3,392 | 26.6 |
| 7 | Sandy clay loams | 527 | 4.1 |

Observations made across the Lake Victoria/Kagera Basin reveals that soil conservation measures across the different landscapes are very limited (Figure 13). Concerns about soil degradation arise out of many studies including the one whose findings are shown in Figure 14. Figure 14, for example, shows that soil conservation measures, for improving soil fertility, are correlated with the size of *shambas*: the bigger the plot, the less likely is an investment by the farmer in soil conservation measures. It is when the size of land has been fragmented, less than 5 acres (2 ha) is some form of soil conservation considered by the communities of the Lake Victoria/Kagera Basin (Figure 14).

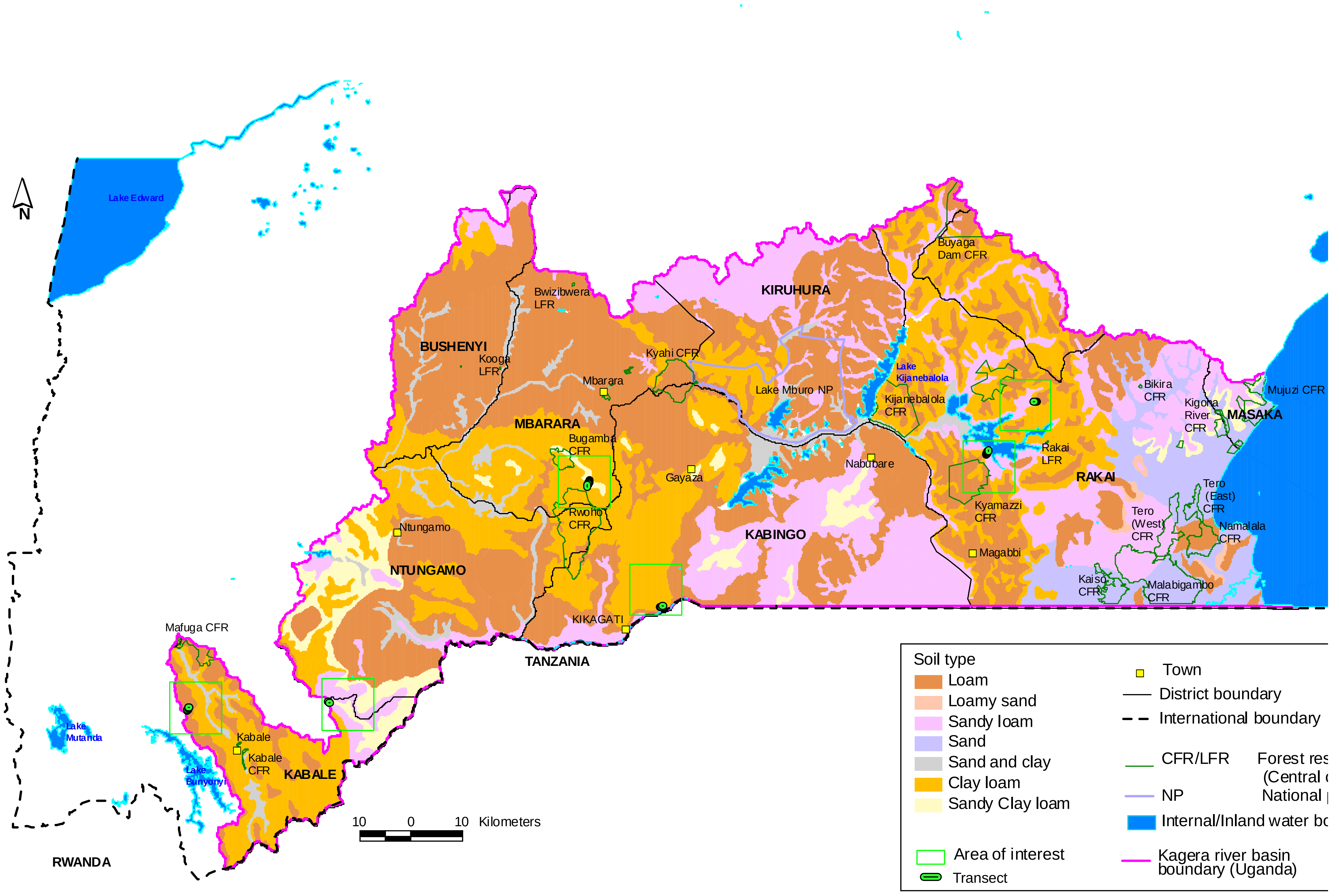



Figure 112 Soils of the Lake Victoria/Kagera Basin.


**Figure 13. Land use in Mbarara District shows no signs of conservation measures against soil erosion.**

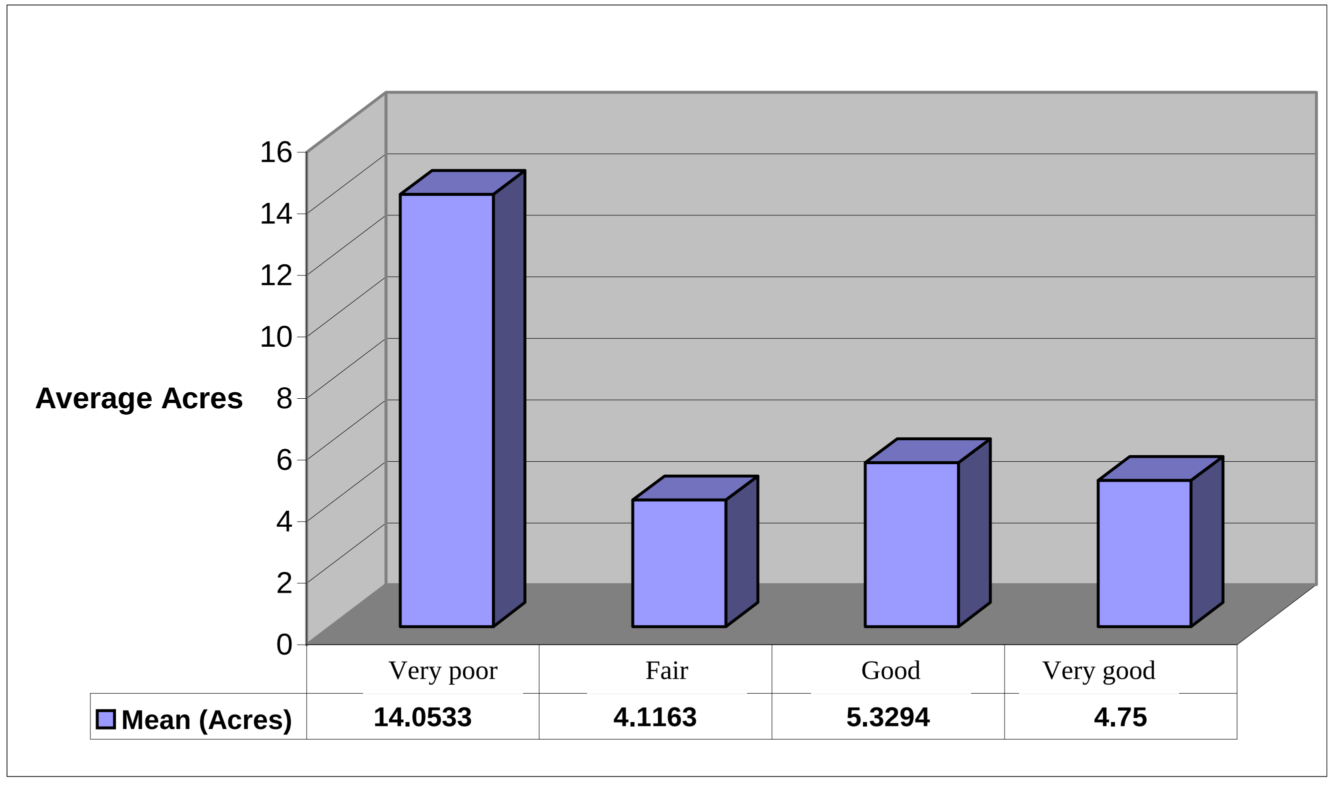



**Figure 14. Decisions to conserve soils, in the Lake Victoria/Kagera Basin, are based on the perceived size of farms** ***[LUCID Working Paper No. 17, J. Tukahirwa (2002)].***

In her study, Tukahirwa (2002) found out that there are several soil conservation measures practiced by the farmers of the Lake Victoria/Kagera (Figure 15). Therefore, there is no doubt that soil degradation (both biological, chemical and physical) is taking place in the Lake Victoria/Kagera Basin. However, chemical fertilizers appear to be gaining more ground than other methods in a country known to have an insignificant per capita use of artificial fertilizers, probably an indication of soil fertility degradation.

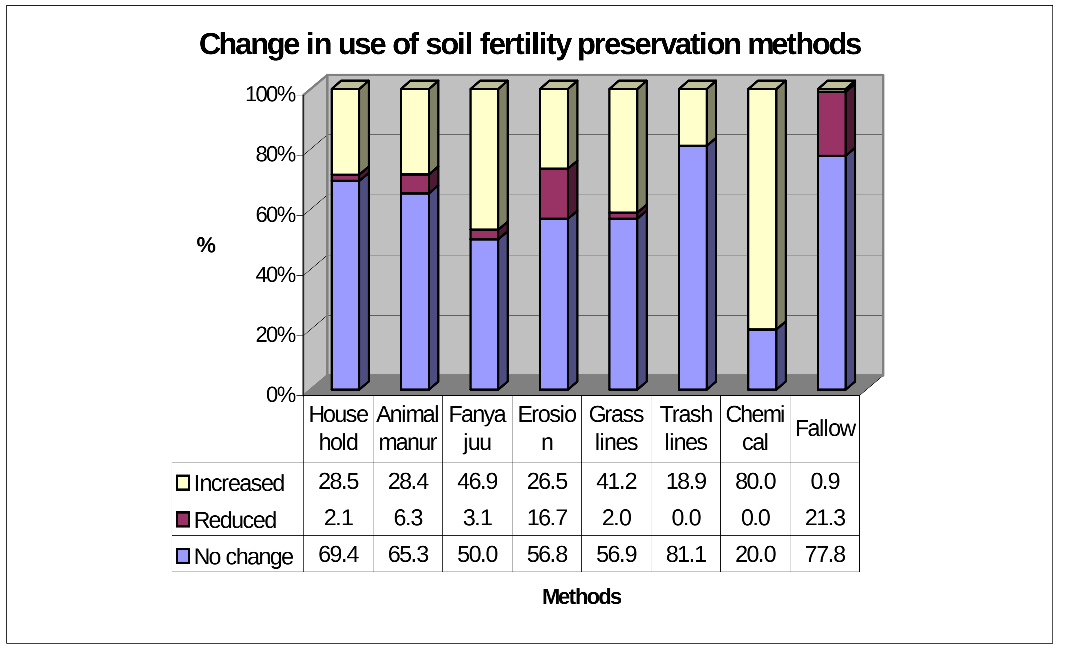



**Figure 15. Types of soil conservation measures practiced in the Lake Victoria/Kagera Basin** ***[LUCID Working Paper No. 17, J. Tukahirwa (2002)].***

### 3.3 Rainfall amount and distribution

The varied types of landforms (from low-lying lacustrine to the high hills of Kabale) together with the influence of Lake Victoria gives rise to significant differences between rainfall amount and distribution across the Lake Victoria/Kagera Basin. The most widespread rainfall zone in the basin is the rangelands of the animal corridor (and surrounding areas) that receive between 1,000 – 1,500 mm of rainfall per annum (Figure 17). The hilly/very hilly and lacustrine landform regions receive the highest amount of rainfall (1,500 – 3,800 mm per annum).

To a large extent, the rainfall amount and distribution is related to the length of the growing periods (giving two distinct growing seasons) in most of the Lake Victoria/Kagera Basin of Uganda. Well distributed rainfall allows the cultivation of bananas and other crops that do not thrive well in prolonged dry seasons.

*(a) Banana and woodlot plantation (foreground)* *(b) Maize plantation (background)*

**Figure 16. Crops grown areas of the Lake Victoria/Kagera Basin with well distributed and enough rainfall year.**

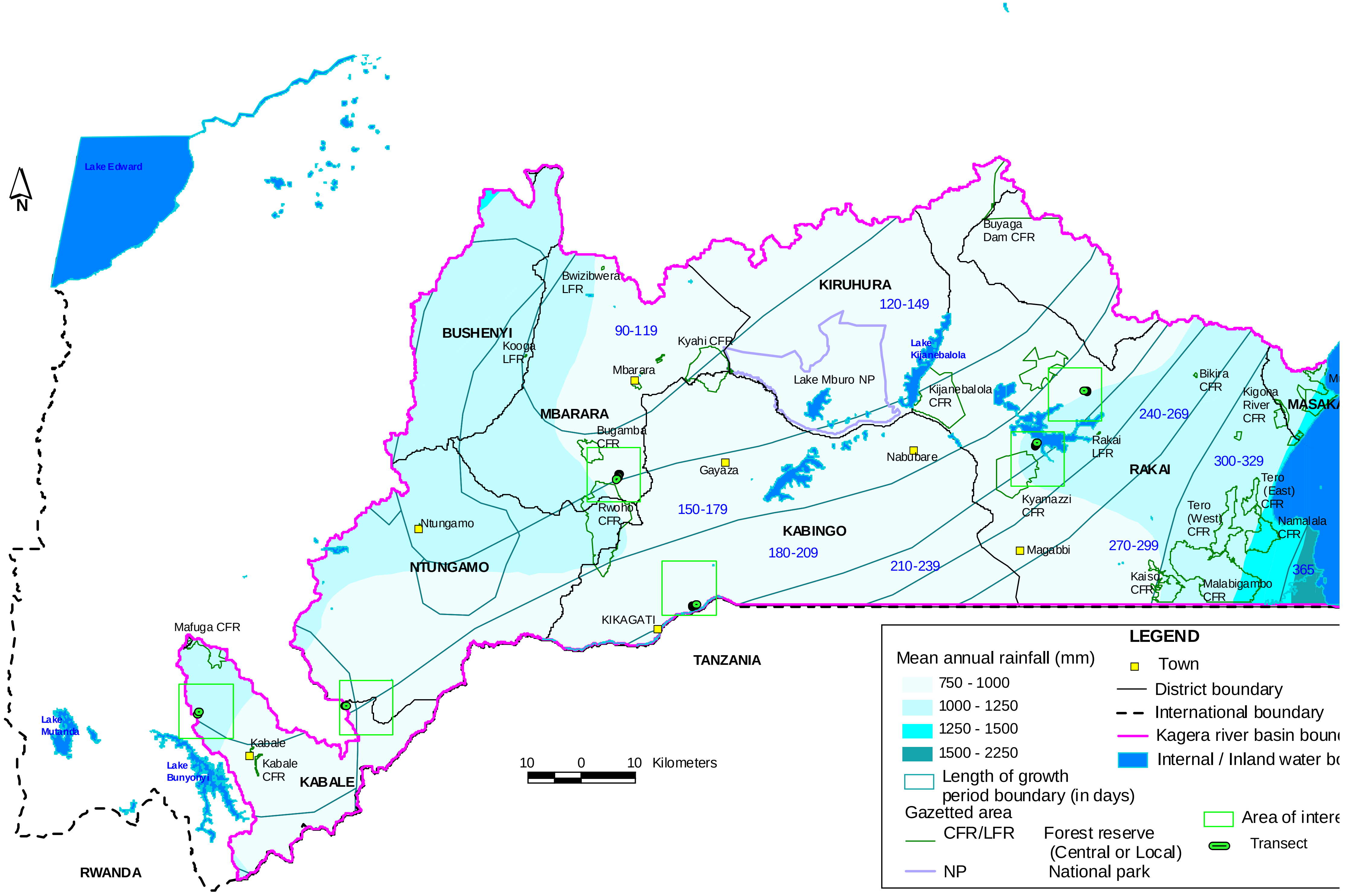



**Figure 17. Rainfall amounts and distribution across the Lake Victoria/Kagera Basin. The isolines enclose zones of the same growing period (in days) for a calendar year.**

Where the length of the growing period is short (mostly the cattle corridor), pastoral activities used to be the dominant land use before the 1990's as depicted in Figure 18). However, of recent charcoal burning has become a major economic activity, especially along the major roads connecting big urban centres. Indeed, there are well founded concerns that the dry savanna woodlands (Figure 19) within the Lake Victoria/Kagera Basin is under threat of irreversible degradation from overgrazing and charcoal industry. In addition, due to shortage of arable land in areas with well distributed and enough rainfall, cultivation of crops is expanding to these fragile rangelands (Figure 20).


**Figure 18. Cattle grazing in the cattle corridor of the Lake Victoria/Kagera Basin.**

**Figure 19. Acacia woodland under threat from charcoal industry along major roads within the Lake Victoria/Kagera Basin.**

**Figure 20. The fragile dry savanna ecosystems (cattle corridor) is under threat from subsistence farming due to decreasing Arable land in the Lake Victoria/Kagera Basin.**

### 3.4 Hydrology

High amounts of rainfall in some areas of the Lake Victoria/Kagera Basin requires extensive drainage systems in form of rivers, wetlands and lakes (Figures 21, 22 and 23). Figure 25 depicts the major drainage systems of the Lake Victoria/Kagera Basin. Given the high rate of destroying water catchment areas in the Lake Victoria/Kagera Basin, there is concern that water resources are being degraded, probably contributing to the drying of lake Victoria.

**Figure 21. Part of River Kagera draining the hills of Burundi, Rwanda and Uganda to Lake Victoria.**

**Figure 22. A wetland that drains part of the lacustrine landform into Lake Victoria.**

**Figure 23. A wetland transformed into a lake in Kabingo District after the El Niño of 6 years ago.**

However, while there are extensive water bodies in the cattle corridor of the Lake Victoria/Kagera Basin, shortage of water, for both humans and animals, during the dry season is of great concern. Figure 24 shows a lady fetching water for domestic use from a heavily silted well.

**Figure 24. A silted well that provides water for domestic use in the cattle corridor of the Lake Victoria/Kagera Basin.**

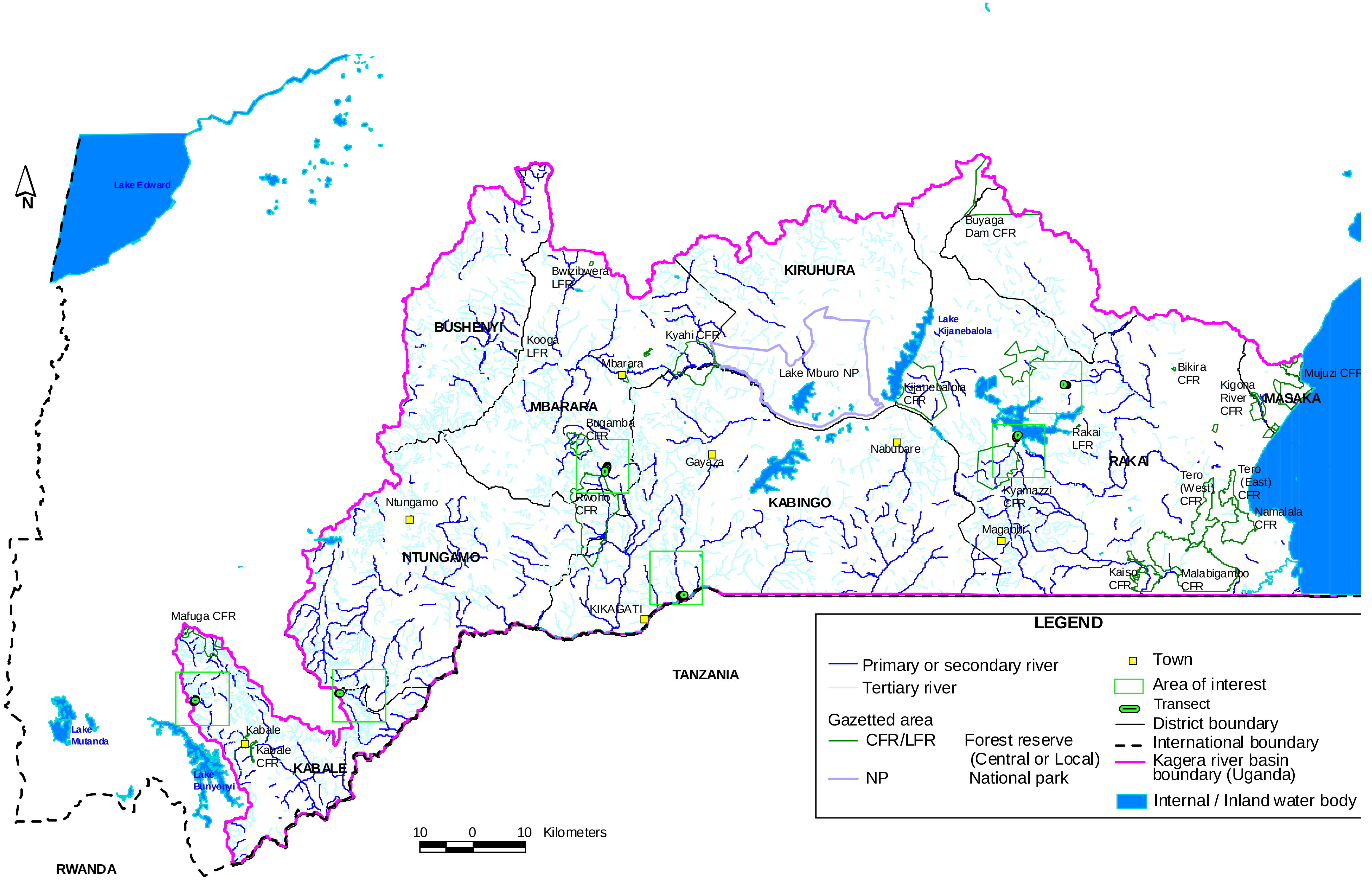



**Figure 25. Hydrological characteristics of the Lake Victoria/Kagera Basin.**

### 3.5 Vegetation

The various soil forming factors (relief, climate, parent materials, human activities) are reflected in the nature of the vegetation of the Lake Victoria/Kagera Basin. Historically, the Lake Victoria/Kagera Basin was dominated with savanna ecosystems (moist thickest, moist acacia, dry acacia and grasslands); wetlands (herbaceous and forested); moist savanna/forest mosaics; rain forests and post-cultivation plant communities. A number of these vegetation types have been depicted in the figures presented in the previous sections, for example Figures 3, 4, 6, 8 and others. Additional vegetation types are shown in Figures 26, 27 and 28.

**Figure 26. Acacia woodland growing in the Lake Victoria/Kagera Basin.**

**Figure 27. Grassland growing in the Lake Victoria/Kagera Basin.**

**Figure 28. A wetland growing in the Lake Victoria/Kagera Basin.**

The geographical distribution of the nature of vegetation of the Lake Victoria/Kagera Basin is shown in Figure 29. Note that the map shown in Figure 29 shows the climax vegetation types as mapped in 1964 (Langdale *et al*., 1964). The map climax vegetation map of Uganda (1964) was produced at a scale of 1:250,000 from aerial photographs acquired in mid 1950s. The vegetation map, accompanied with descriptions of all mapped plant communities, provides a valuable baseline for the FAO/GEF/TAMP future activities related directly with degradation of vegetation in selected sites of the Lake Victoria/Kagera Basin over the past 50 years.

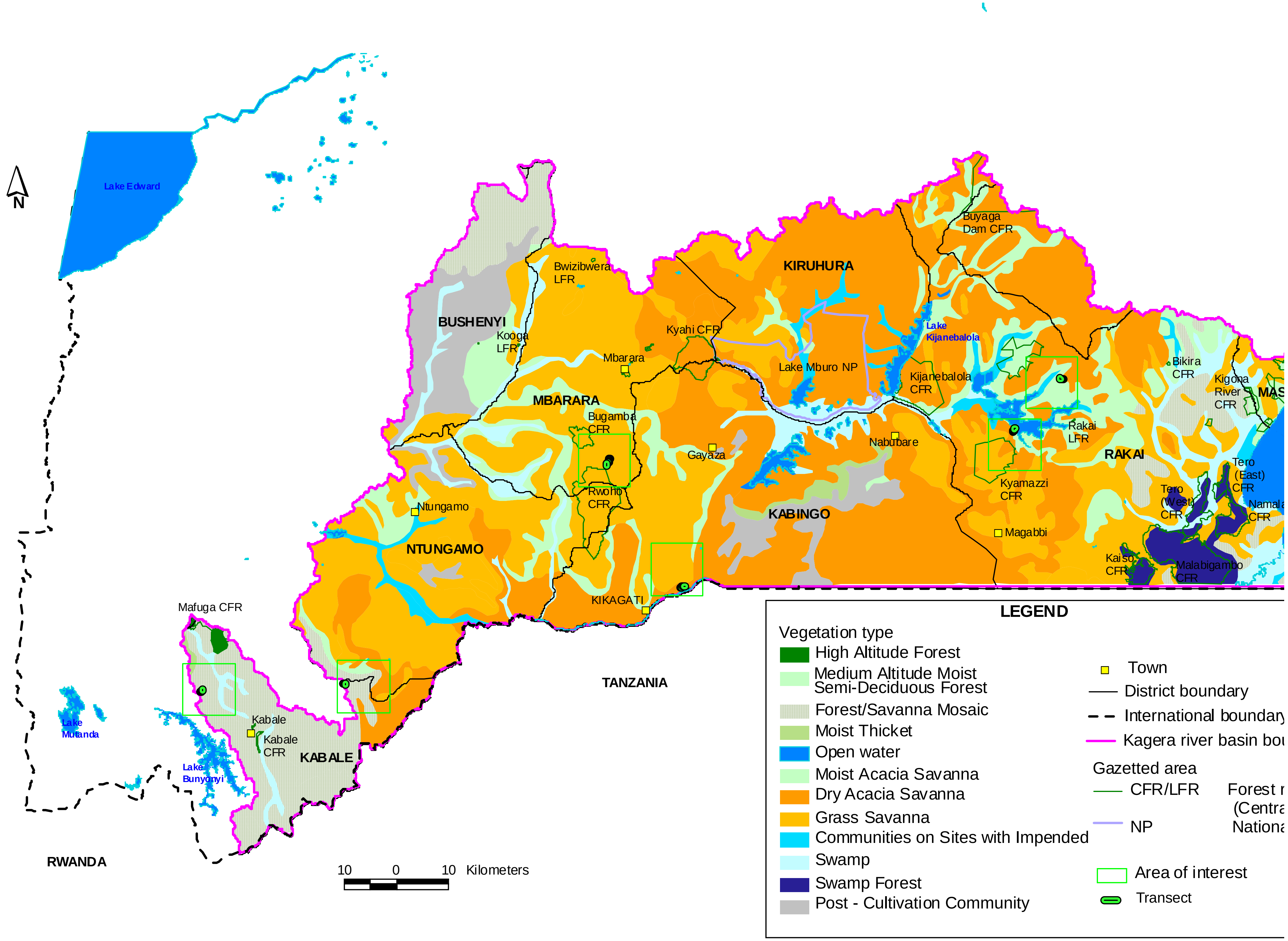



Figure 29. climax vegetation types (1964) of the Lake Victoria/Kagera Basin.

### 3.6 Land cover

To an extent, Uganda is blessed with two land cover maps derived from SPOT XS imagery acquired in 1990 and more recently from Landsat TM acquired in 2000. The two land cover maps were produced by two separate projects at different times and were funded by the Norwegian Forestry Society and FAO respectively. The two land cover maps, produced at cartographic scales of 1:50,000 and 1:100,000 respectively, provide much needed information about the extent and distribution of major land cover types (both natural as well as human made ecosystems) for many different uses within Uganda and beyond. The extent and location of the remaining critical ecosystems (rain forests, wetlands, savannas) and farmed ecosystems are now computed from the two land cover maps produced from SPOT XS (1990) and Landsat TM (2000) for Uganda. Such computations have also been made for FAO-TAMP GIS study and shown in Table 3 from land cover maps presented in Figures 31 and 32.

**Table 3. Computed areal extents (based on the 1990 and 2002 satellite imagery) of major land cover categories found within the Lake Victoria/Kagera Basin . Note: calculation is based on the geographic extent of all the TAMP-Uganda districts.**

| Land us/cover | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1990 | | | 2002 | | |
| | Area ($km^2$) | No. of mapping units | Average size ($km^2$) | Area ($km^2$) | No. of mapping units | Average size ($km^2$) |
| Broad-leaved tree plantations | 37.8 | 1 | 37.8 | | | |
| Coniferous plantations | 34.3 | 14 | 2.4 | | | |
| Tropical high forests | 262.8 | 78 | 3.4 | 254.7 | 18 | 14.2 |
| Degraded high forests | 30.3 | 116 | 0.3 | 43.1 | 16 | 2.7 |
| Woodland | 313 | 451 | 0.7 | 1357.8 | 237 | 5.7 |
| Bushland | 2,024.6 | 484 | 4.2 | 2844.4 | 368 | 7.8 |
| Grassland | 7,819.4 | 1387 | 5.6 | 5,200.5 | 652 | 8 |
| Wetland | 366.9 | 241 | 1.52 | 1402.7 | 151 | 9.3 |
| Subsistence farming | 5,626.3 | 1823 | 3.1 | 4,615 | 567 | 8.1 |
| Large scale farming | 2.4 | 4 | 0.59 | 21.4 | 1 | 21.4 |
| Built - up areas | 20.2 | 124 | 0.16 | 17 | 18 | 0.9 |
| Water bodies | 204 | 85 | 2.4 | 212 | 20 | 10.6 |
| Rocks/bare ground | 2.2 | 48 | 0.046 | 0 | | |

While the two maps were produced using different land cover classification systems, it was easy to generalise the legend of the FAO Africover map to the broad land cover categories mapped in 1990 from SPOT XS data for purposes of comparing the two maps (Table 3). The computed areal extents of the broad and major land cover types for 1990 and 2002 shows both differences and similarities. For example, forest plantations (both broad-leaved and coniferous) and rocks/bare grounds were not identified and mapped in the Lake Victoria/Kagera Basin by the FAO Africover team in Uganda. Probably this can be explained by the higher image resolution of SPOT XS data (20 m) compared with that Landsat TM (30 m). The similarities, in statistical terms, between the two maps is shown by the amount of tropical forests (degraded or not), built-up areas, and water bodies. However, there are also significant differences in the extent and distribution of woodlands, bushlands, grasslands, wetlands, and subsistence farmed ecosystems. These differences are of much concern because they seem to be attributed to image classification errors. As part of the FAO-TAMP GIS study, MUIENR Geographic Services' team has conducted a ground truthing exercise to determine the accuracy of FAO Africover map in the Lake Victoria/Kagera Basin. An error classification matrix will be included in due course before the final report is delivered to FAO-TAMP on 28 Feb 2006.

As an error matrix is awaited, one can infer from theoretical considerations that an accurate quantification of land use/cover may not be fully realizable from single-date satellite imagery (SPOT XS and Landsat TM m). This is because the same geographical features (even if they have not changed between 1990 and 2002) may exhibit different spectral signatures, depending on the health status of the leaves of different plant communities. For example, while there is no evidence of riverine forests on part of a land cover map derived from SPOT XS (1990), the FAO Africover team identified and mapped significant riverine forests in the same piece of terrain (Figure 30). The same discrepancy between the two maps is indicated on the maps on the right where there is more forest cover identified and mapped from the 1990 SPOT XS data than the TM-derived map. Since both land cover maps (1990 and 2002) were produced using the same image classification techniques, the differences can realistically be attributed to changes in plant *phenology* from season to season, a phenomenon that most image analysts tend to ignore during mapping.

A related problem that may explain the significant differences between the extent and distribution of woodlands, bushlands, grasslands, wetlands, and subsistence farmed ecosystems in the Lake Victoria/Kagera Basin is the difficulty of differentiating between, spectrally, such land cover classes. Even though woodlands and bushlands are different structurally on the ground, they are the same spectrally (from space). Similarly, they are bushland- and grassland-like crop land covers and hence, the potential of misclassifications is high among woodlands, bushlands, grasslands, wetlands, and subsistence farmed ecosystems. Because of the significant discrepancies between the 1990 SPOT XS- and 2002 Landsat TM-derived land cover maps within the Lake Victoria/Kagera Basin in Uganda, land cover change analysis, based on the two maps, was not carried out in order to avoid error propagation. MUIENR Geographic Service' team has embarked on a more robust land cover change analysis exercise for the Lake Victoria/Kagera Basin and other regions of Uganda using land cover maps derived from aerial photographs acquired in mid 1950's and ASTER data acquired in 2005. Since the exercise is expected to take about 12 months from February 2006, the information will be available to FAO-TAMP project at a later date.

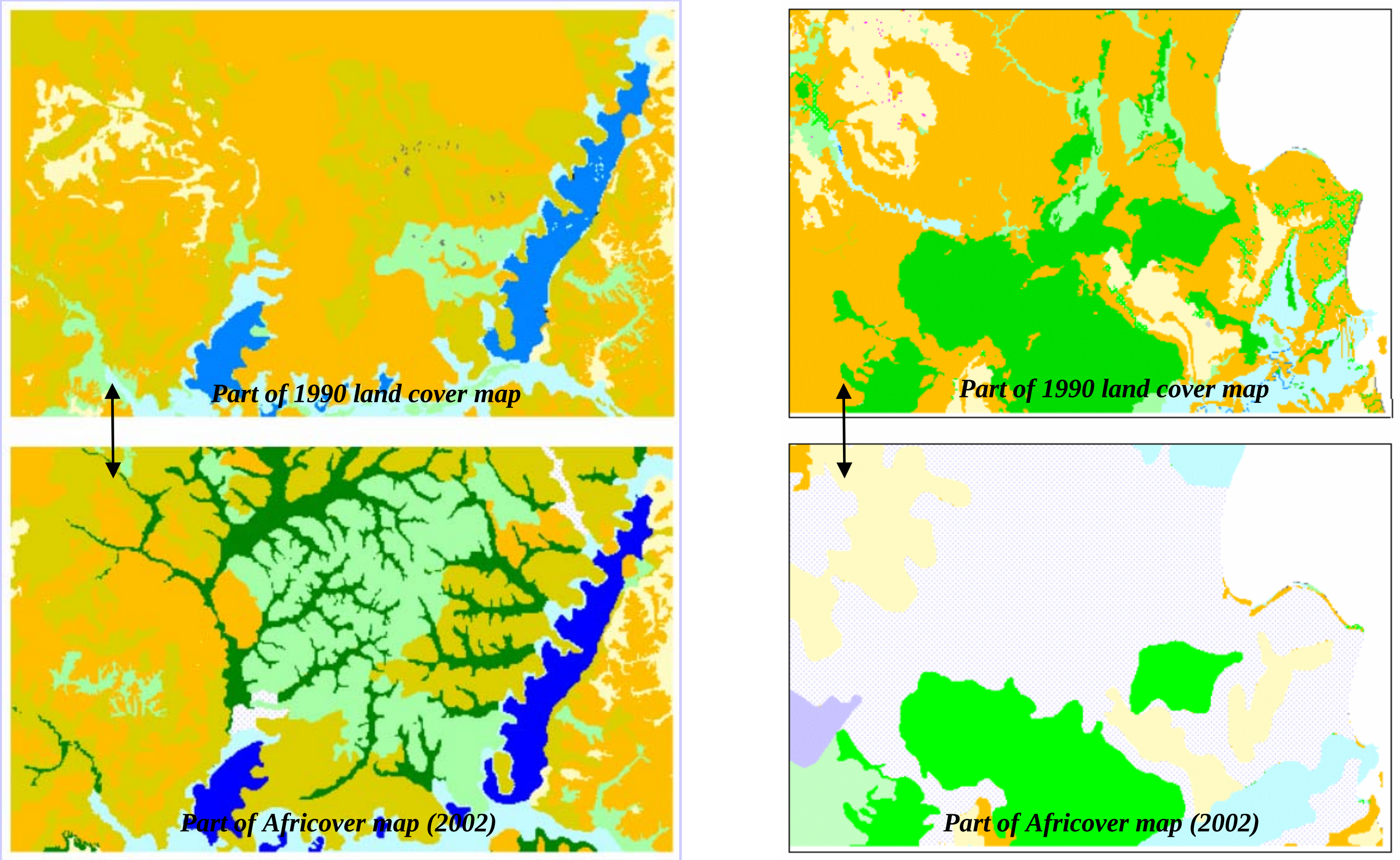



**Figure 30. climax vegetation types (1964) of the Lake Victoria/Kagera Basin.**

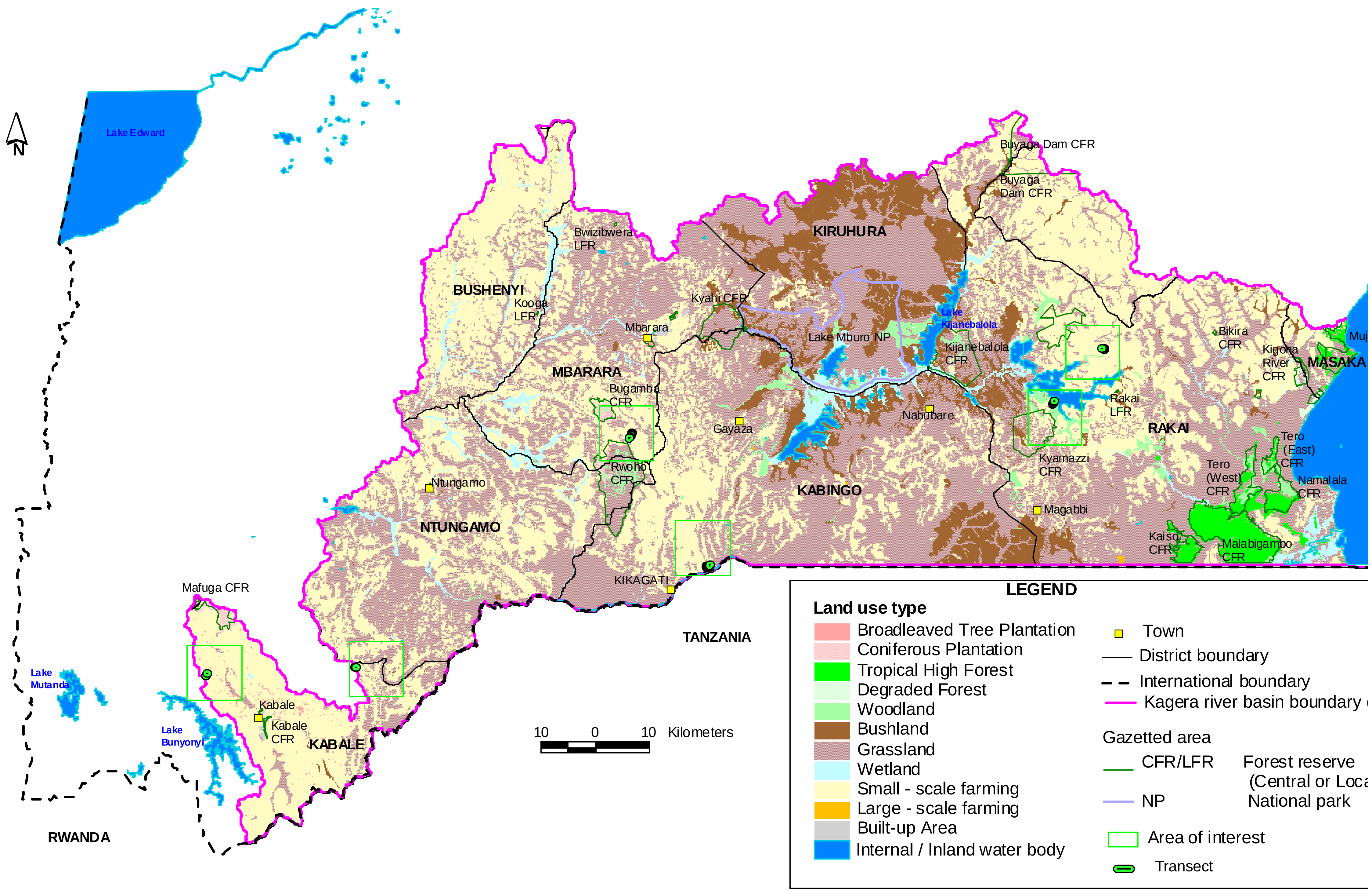



Figure 31. Land cover types (1990) of the Lake Victoria/Kagera Basin derived from SPOT XS by the National Biomass Project.

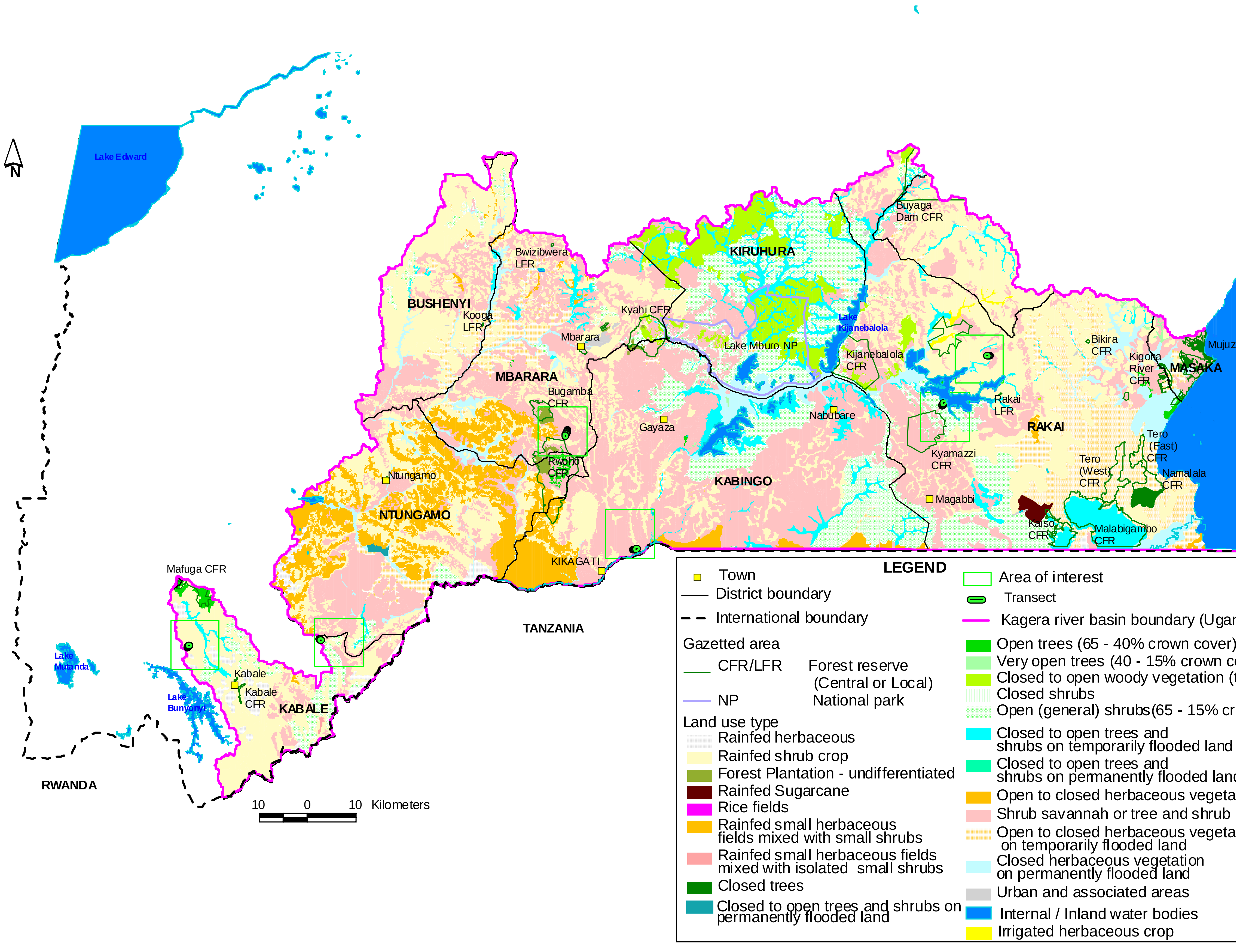



**Figure 32. Land cover types (1990) of the Lake Victoria/Kagera Basin derived from Landsat TM (Africover Project).**

### 3.7 Land use

Due to the fact that the Lake Victoria/Kagera Basin of Uganda is well endowed with rainfall of different regimes, relatively fertile soils, and probably hard working people, agricultural production of crop and animal products is among the highest in the country. Broadly, the major land use categories range from forestry, fishing, cattle keeping to crop farming. These four broad land uses are practiced to varying extents and distributions across the Lake Victoria/Kagera Basin but Table 4 shows the amount of land estimated to be under each of the land uses: forestry products (340 $km^2$); pastoralism (9,200 $km^2$ and 2,500 $km^2$ ), fishing (890 $km^2$) and both large/small farming (4,450 $km^2$).

**Table 4. Computed areal extents, in $km^2$, (based on the Africover 2002 land cover map) of major land uses within the Lake Victoria/Kagera Basin . Note: propagation of errors is expected in the computed values as noted in the previous section.**

| District | Forest | Rangeland | Wetland | Large-scale farmland | Small-scale farmland | Water bodies |
|---|---|---|---|---|---|---|
| Kabale | 116 | 344 | 41 | | 1,047 | 67 |
| Kabingo | 2 | 1,987 | 265 | | 358 | 33 |
| Kiruhura | 156 | 3,277 | 689 | 0 | 443 | 37 |
| Mbarara | 9 | 935 | 219 | | 602 | 0 |
| Ntungamo | 12 | 1,116 | 140 | | 718 | 8 |
| Rakai | 45 | 1,570 | 1,239 | 21 | 1,263 | 748 |
| **Grand Total** | **340** | **9,229** | **2,594** | **22** | **4,430** | **893** |

Key crops grown in the the Lake Victoria/Kagera Basin of Uganda include bananas, coffee, maize, beans, millet and potatoes. The relative proportion of the crops grown is shown in Figure 33 and their geographic distribution in Figure 35. As shown in Figure 33, bananas, beans, maize and sweet potatoes are the dominant crops. Most of the bananas consumed in all major urban areas of Uganda originate from the Lake Victoria/Kagera Basin of Uganda.

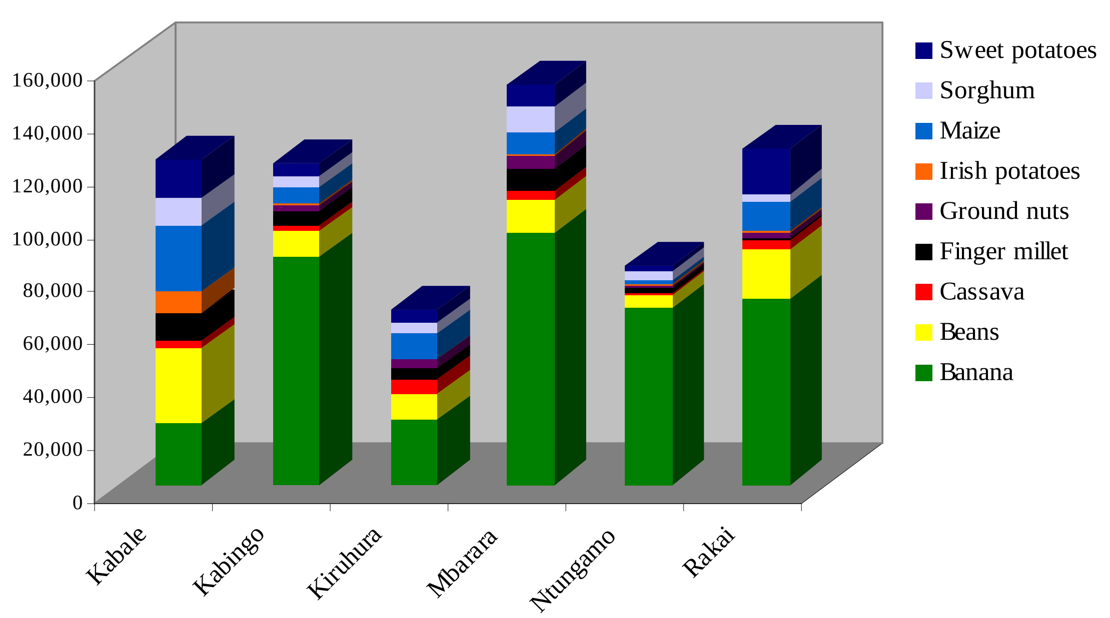



**Figure 33. The amount of areal extent, in ha, of crops grown in the Lake Victoria/Kagera Basin (Agricultural census data, 1987)**

It is not surprising that livestock rearing is widespread given the extensive rangelands of the Lake Victoria/Kagera Basin of Uganda. Figure 35(a) shows the numbers of livestock, per category, within the Lake Victoria/Kagera Basin of Uganda. Cattle is the most favored type of livestock reared in the region, followed by goats in each of the districts that contributes land to the Lake Victoria/Kagera Basin of Uganda [Figure 35(a)]. Figure 35(b) shows the methods used to feed the livestock, according to the local communities, reared in the Lake Victoria/Kagera Basin.

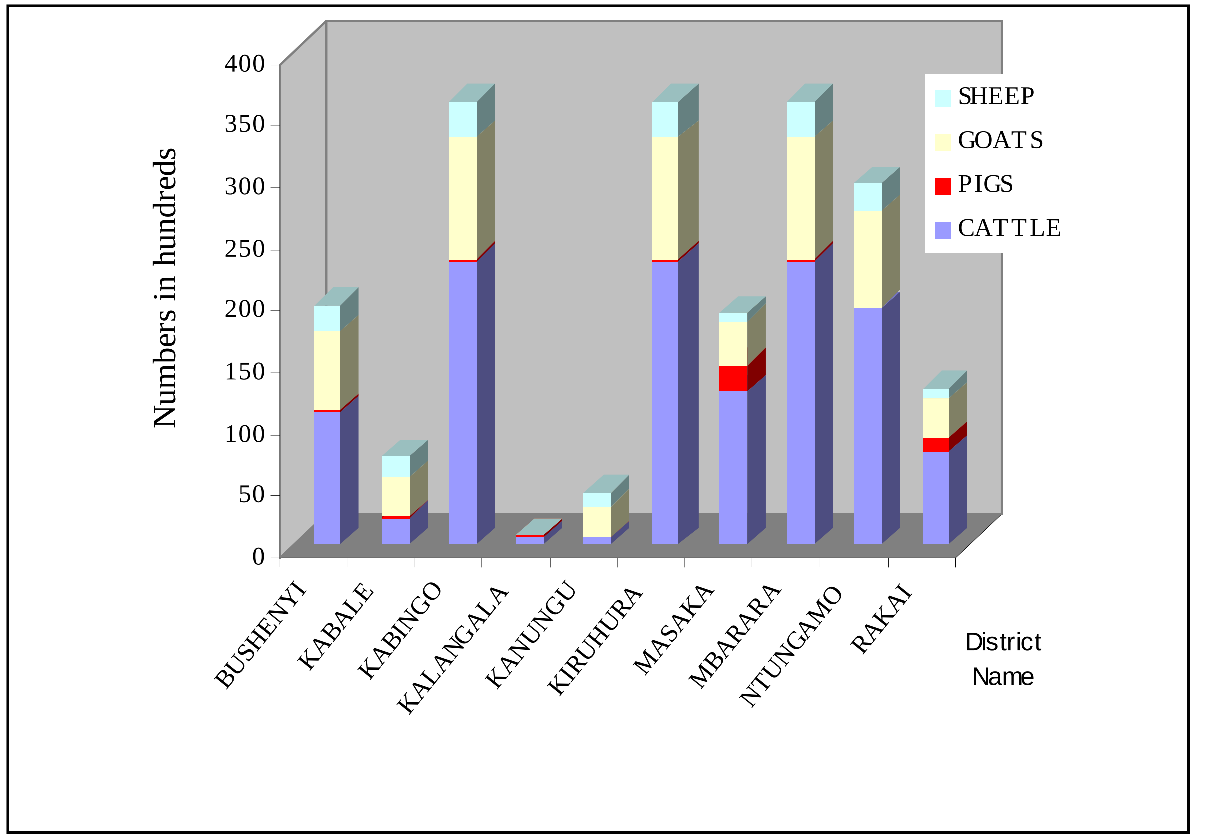



**Figure 35(a). The numbers of livestock reared in the Lake Victoria/Kagera Basin (Agricultural census data, 1987)**

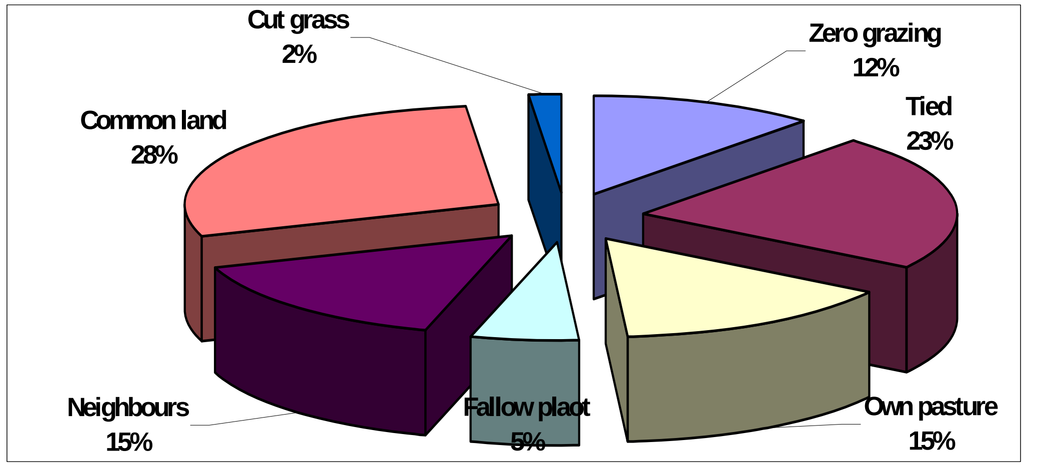



**Figure 35(b). The method of feeding livestock reared in the Lake Victoria/Kagera Basin *[LUCID Working Paper No. 17, J. Tukahirwa (2002)].***

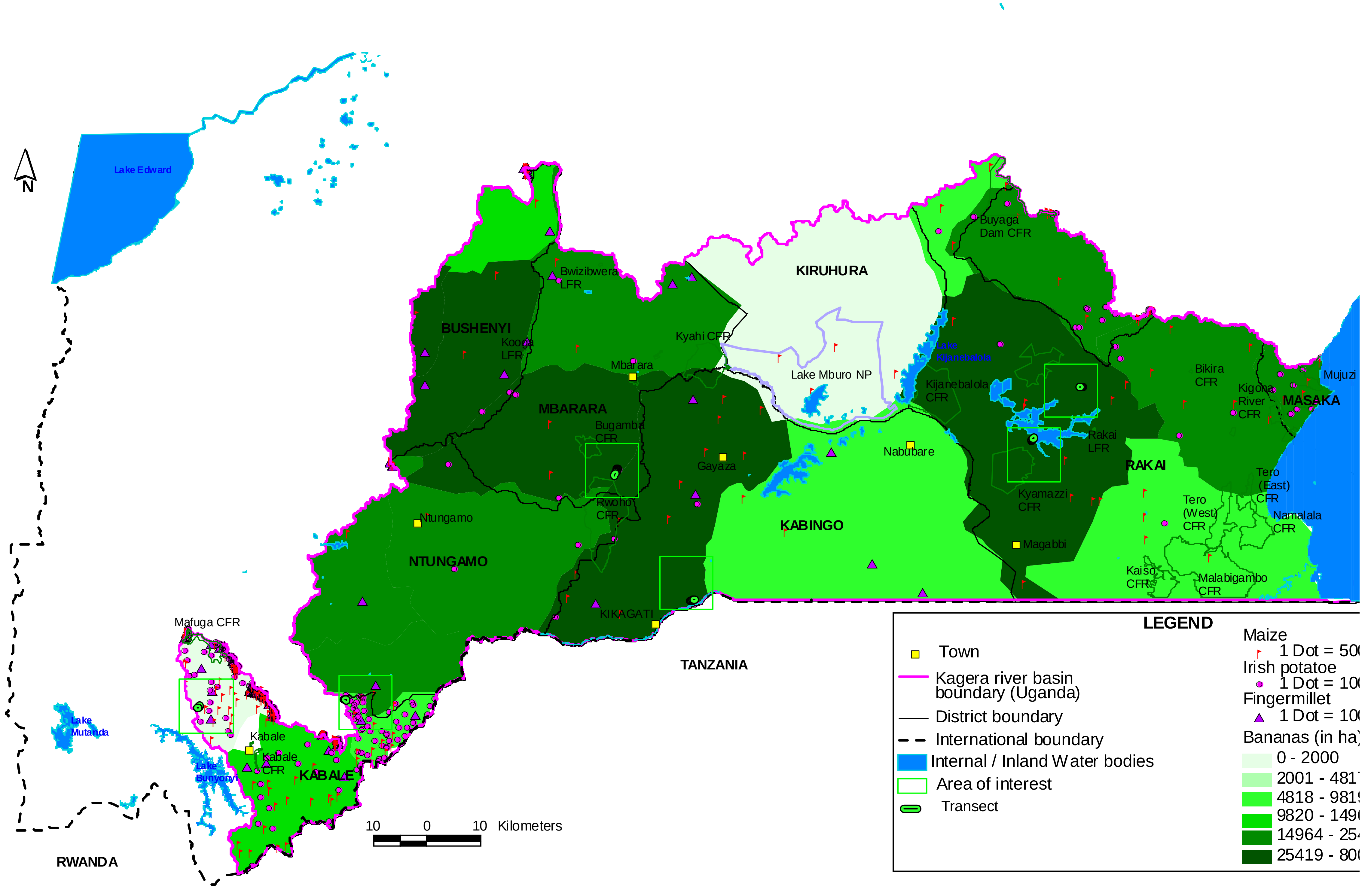



**Figure 35. Geographic distribution of key crops in the Lake Victoria/Kagera Basin (Source, ILRI, GIS database).**

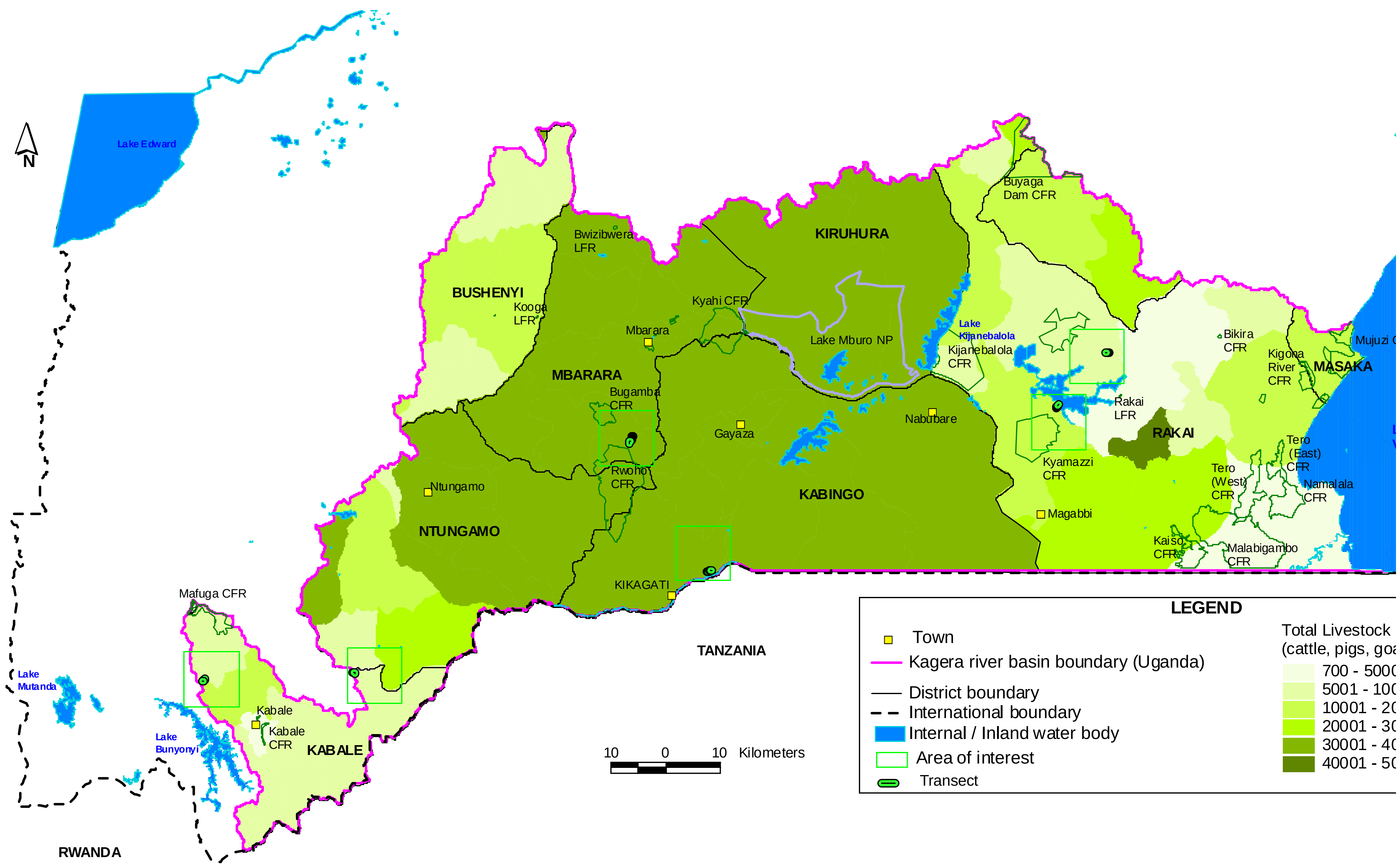



**Figure 36. Geographic distribution of livestock reared in the Lake Victoria/Kagera Basin (Source, ILRI, GIS database).**

### 3.8 Infrastructure

The infrastructure of the Lake Victoria/Kagera Basin of Uganda is similar to that of most developing countries. For example, while Uganda is considered to be covered by a relatively good road network compared to its neighbours like Tanzania and DR Congo, most areas in the Lake Victoria/Kagera Basin of the country are still remote and accessible by dusty/muddy roads that are not well maintained (Figure 37). However, there are two bitumen-surfaced roads that traverse the region (Masaka-Mutukura and Masaka-Mbarara-Kabale-Katuna Roads). Part of Masaka Mbarara Road is shown in Figure 38. The entire distribution of the road network is shown in Figure 40.

**Figure 37. Part of a rural road meandering within the Lake Victoria/Kagera Basin .**

**Figure 38. Part of a highway road within the Lake Victoria/Kagera Basin .**

Apart from the road network shown in Figure 40, the other types of infrastructure that may be of relevance to a development project like FAO-TAMP are the location and distribution of settlements; public amenities like schools, health centres, and water points; and financial credit institutions. An Atlas of Water boreholes and protected springs has been prepared by the Uganda Directorate of Water Development, schools and health centres have been mapped by Ministries of Education/Sports and Health respectively. However, the data about schools and health centres have not been released for official use and hence was not included in this report. What is included in this report is the location and distribution of the most recent micro finance institutions (Figure 39) mapped by MUIENR Geographic services on behalf of a “Financial Deepening Project” funded by DFID in Uganda; and historical settlements (for mid 1950s) being mapped by MUIENR Geographic services for another project (Figure 41). It is important to note that the distribution of micro finance institutions is closely related to population density. With regards to human settlements, the reader is reminded that Uganda’s settlements are overwhelmingly rural and unplanned - settlements are part of peoples’ arable land.

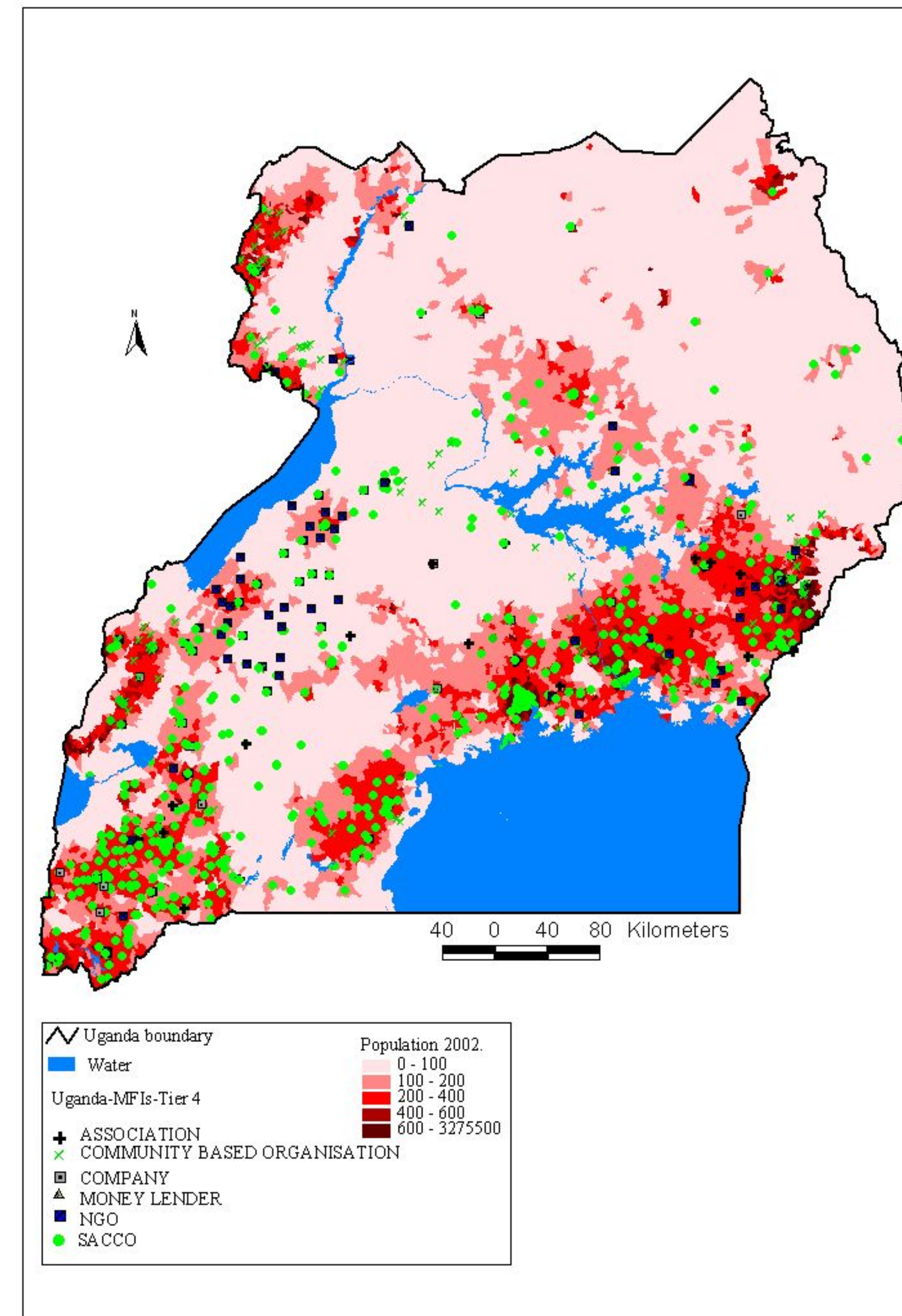



**Figure 39. Distribution of micro finance institutions in Uganda (2006).**

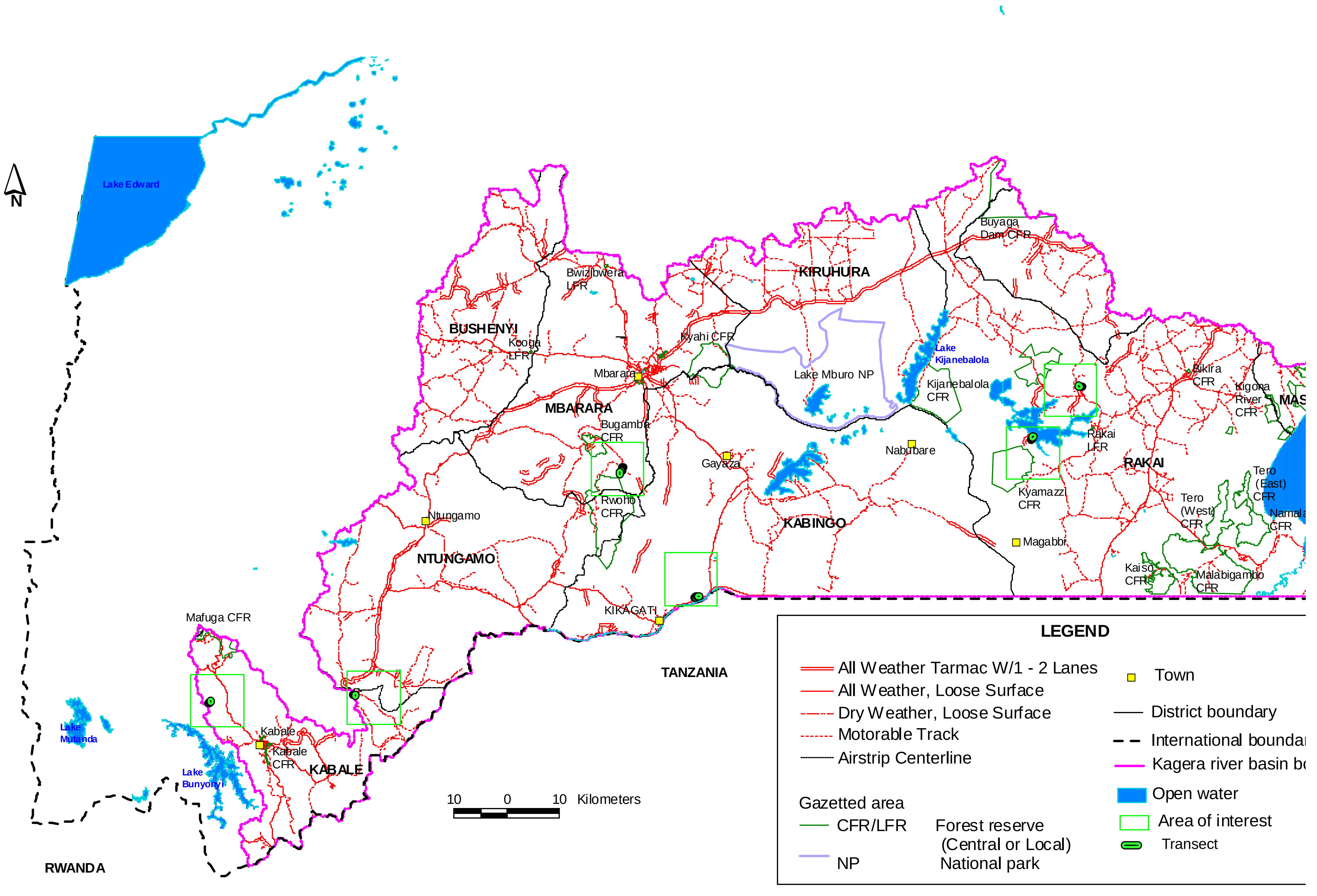



**Figure 40. Geographic distribution of major roads and market centres (urban areas) within the Lake Victoria/Kagera Basin.**

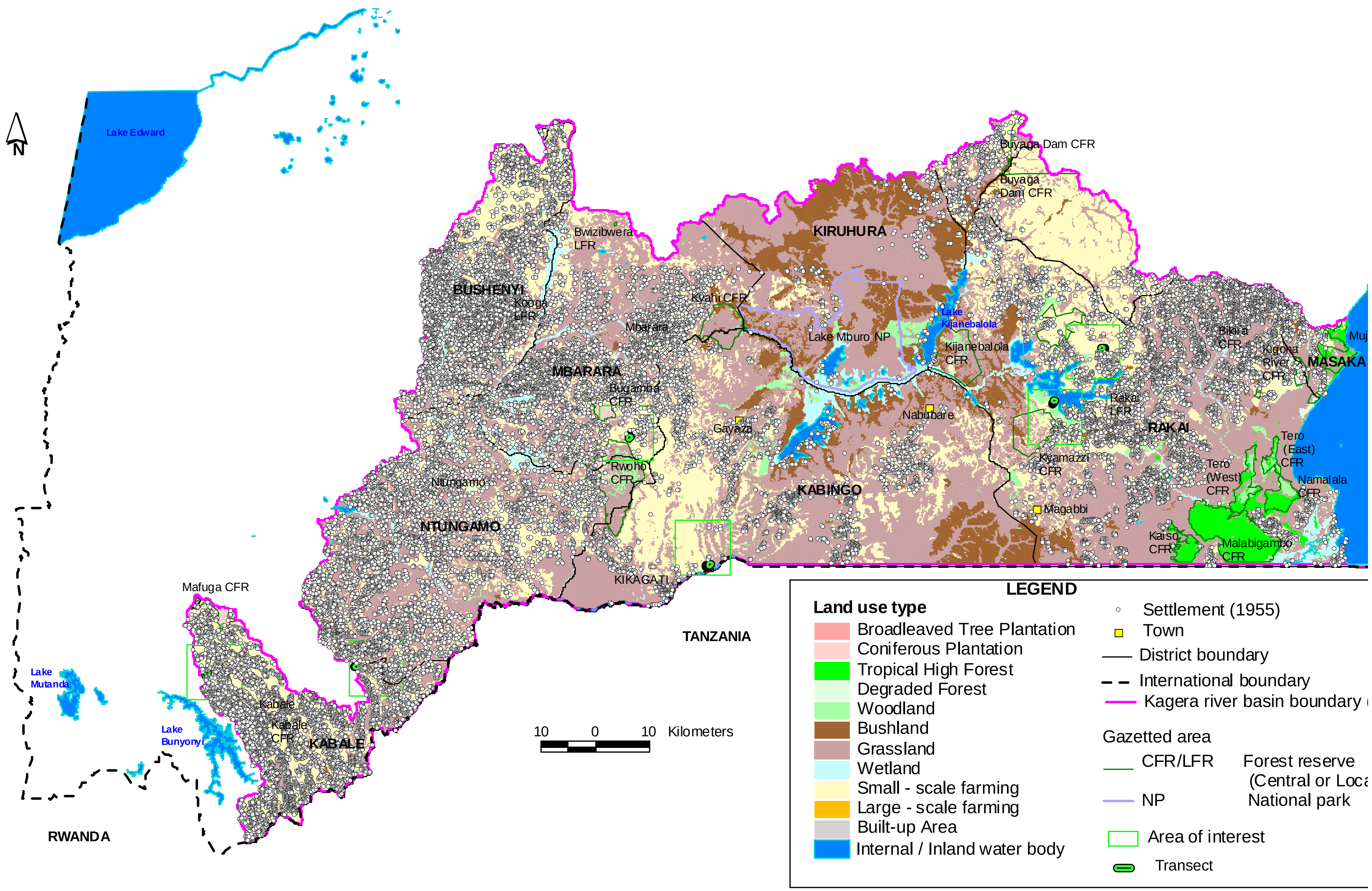



**Figure 41. Distribution of 1955 settlements, superimposed on 1990 land cover/use map, within the Lake Victoria/Kagera Basin**

### 3.9 Demographic characteristics

The demographic characteristics of the Lake Victoria/Kagera Basin of Uganda is heavily influenced by the presence of well distributed and enough rainfall regimes, fertile soils and to some extent the availability of infrastructure especially the road network. Population census, for Uganda, were first taken in 1911 and many other censuses have been conducted since then. Like many other developing countries, the population of Uganda has been on an upward trend (Figure 42) where Uganda is reported as having one of the highest population growth (3.4%) in the world. The household and population numbers obtained for the 1991 and 2002 population censuses, for the Lake Victoria/Kagera Basin of Uganda, are depicted in Table 5.

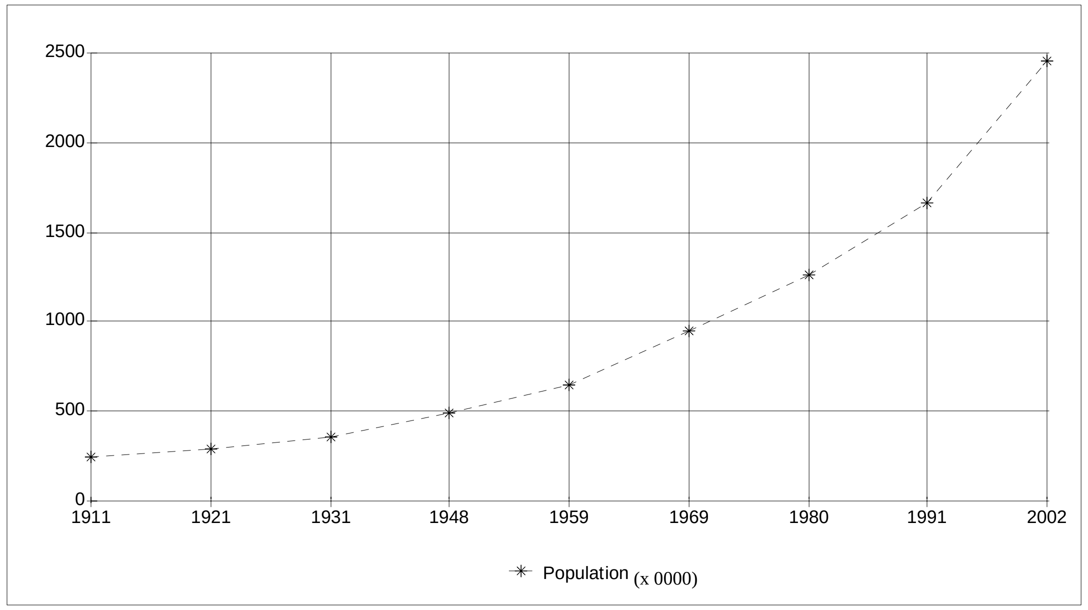



**Figure 42. Population trends in Uganda**

**Table 5. Household and population numbers derived from the 1991 and 2002 censuses.**

| District | Number of house holds | | | | Population numbers | | | |
|---|---|---|---|---|---|---|---|---|
| | 1991 | 2002 | Increment | Change (%) | 1991 | 2002 | Increment | Change (%) |
| Kabale | 82,398 | 95,071 | 12,673 | 15.4 | 414,940 | 458,318 | 43,378 | 10.5 |
| Ntungamo | 51,957 | 76,428 | 24,471 | 47.1 | 305,179 | 379,987 | 74,808 | 25.5 |
| Mbarara | 146,051 | 223,038 | 76,987 | 52.7 | 772,854 | 1,078,951 | 306,097 | 40.6 |
| Rakai | 82,707 | 106,685 | 23,978 | 29.0 | 383,501 | 470,365 | 86,864 | 23.7 |
| **Total** | **363,113** | **501,222** | **138,109** | **38.0** | **1,876,474** | **2,387,621** | **511,147** | **27.2** |

Across the Lake Victoria/Kagera Basin of Uganda, the population densities are dependant on rainfall regimes. This is not surprising because Uganda's population is overwhelmingly agrarian and depends on farming characterised by very low agricultural inputs (since the use of artificial fertilizers, improved seed, powered machines or irrigation is not the norm). Therefore, the cattle corridor, characterised by insufficient soil moisture, is associated with low population densities. This is particularly so for the population information of 1991 (Figure 44). However, data from the recent population census (2002) show that the population density of the Lake Victoria/Kagera Basin of Uganda is increasing, even in large parts of the cattle corridor (Figure 45). In other words, fragile ecosystems (rangelands, upper parts of hills, and the lacustrine sandy soils) are gradually being brought under cultivation. This expansion of destructive human activities into fragile ecosystems will have a degrading effect on natural vegetation and subsequently the catchment areas of the Kagera River. A significant number of the people who are converting fragile ecosystems to farmed ecosystems would have migrated from very high density areas of the Lake Victoria/Kagera Basin of Uganda (Figure 43) due to insufficient arable land. Figure 46 shows areas across the Lake Victoria/Kagera Basin where population density changed over between 1991 - 2002.

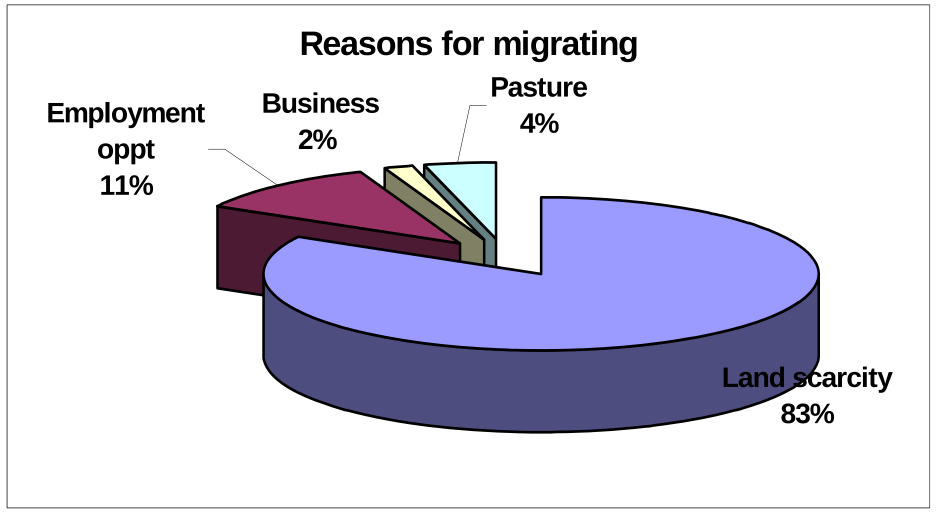



**Figure 43(a). Reasons for migration of people in the Lake Victoria/Kagera Basin *[LUCID Working Paper No. 17, J. Tukahirwa (2002)].***

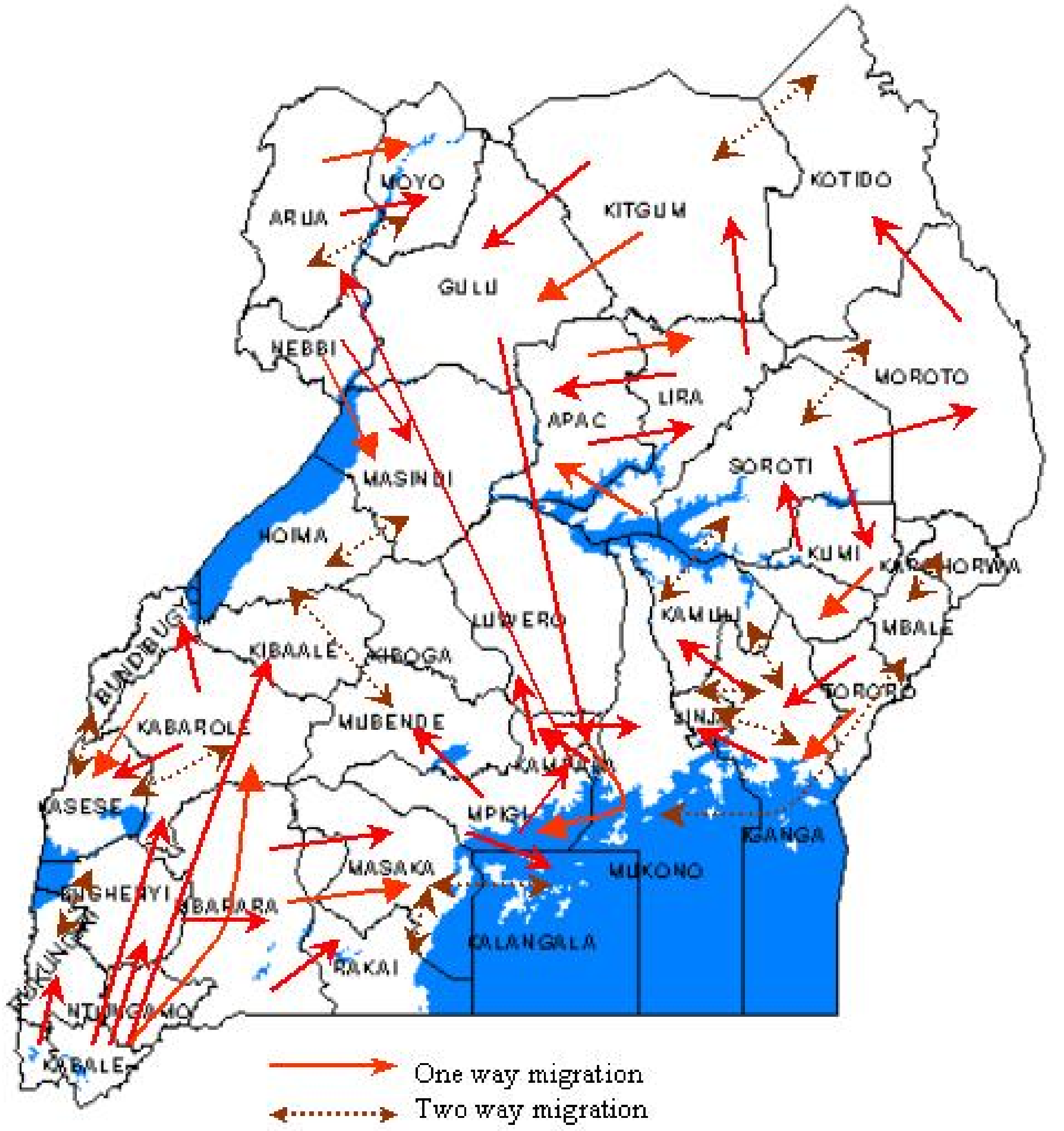



**Figure 43(b). Types of internal human population migration in Uganda (based on 1991 population data).**

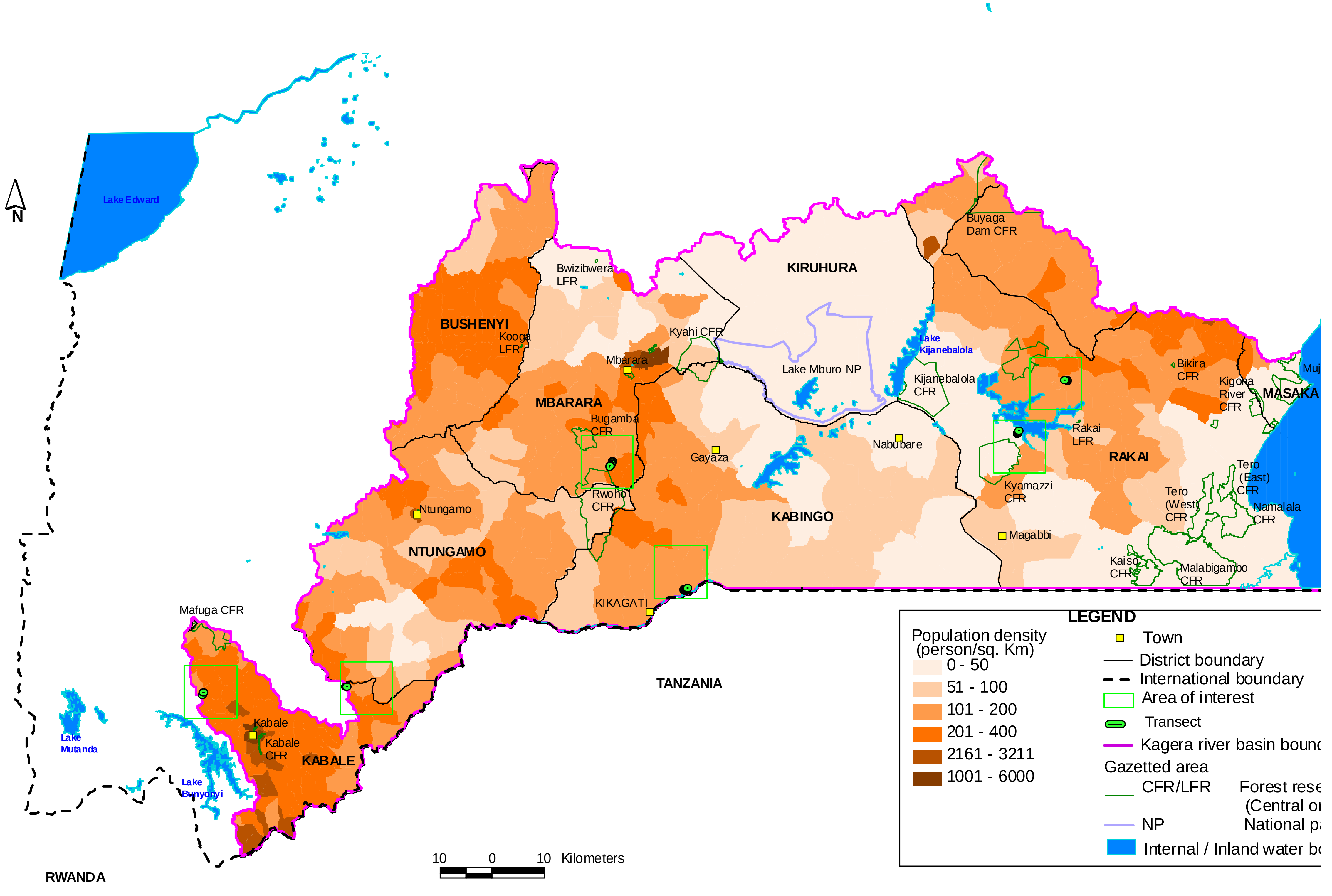



Figure 44. Population density within the Lake Victoria/Kagera Basin within Uganda (1991).

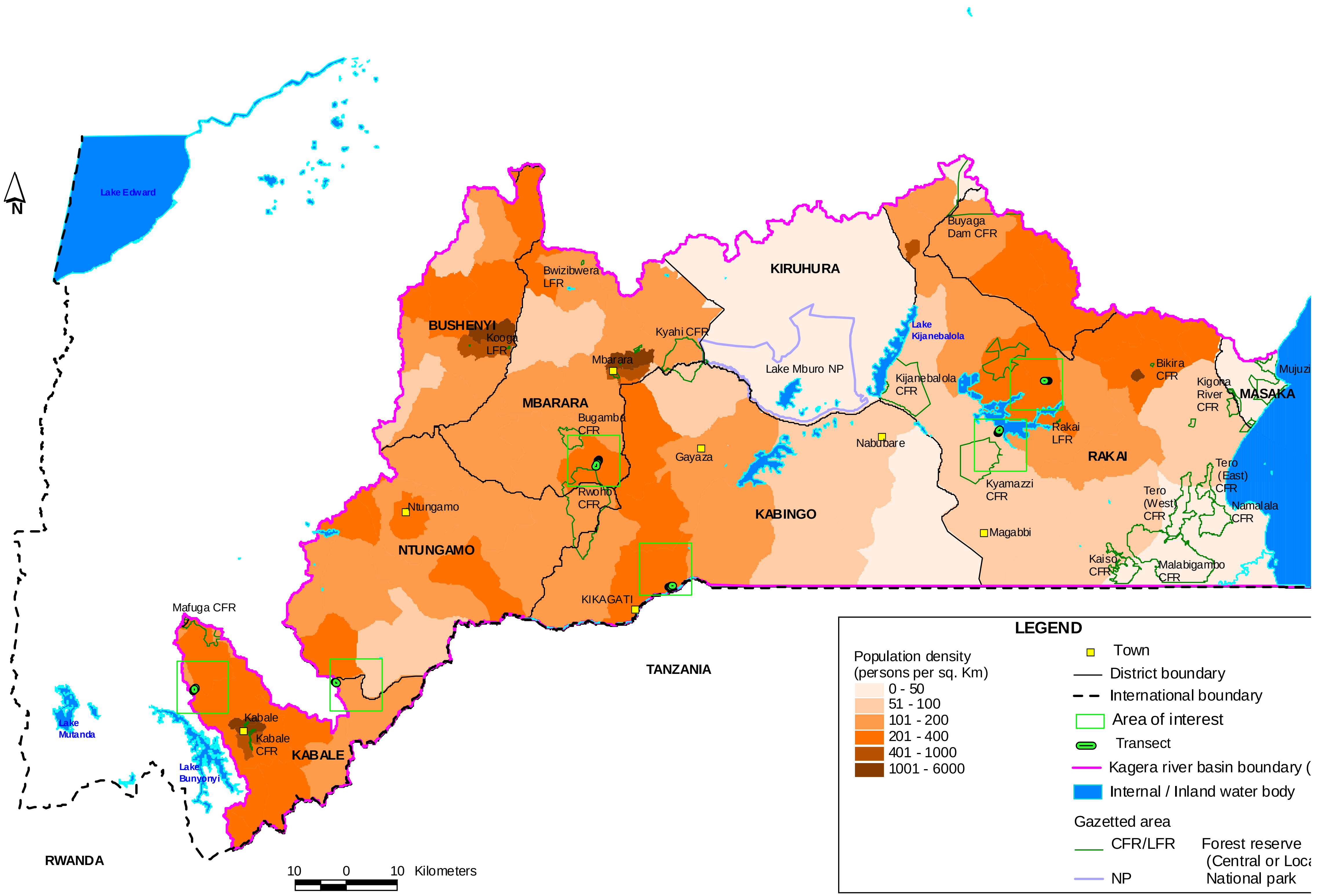



**Figure 45. Population density within the Lake Victoria/Kagera Basin within Uganda (1991).**

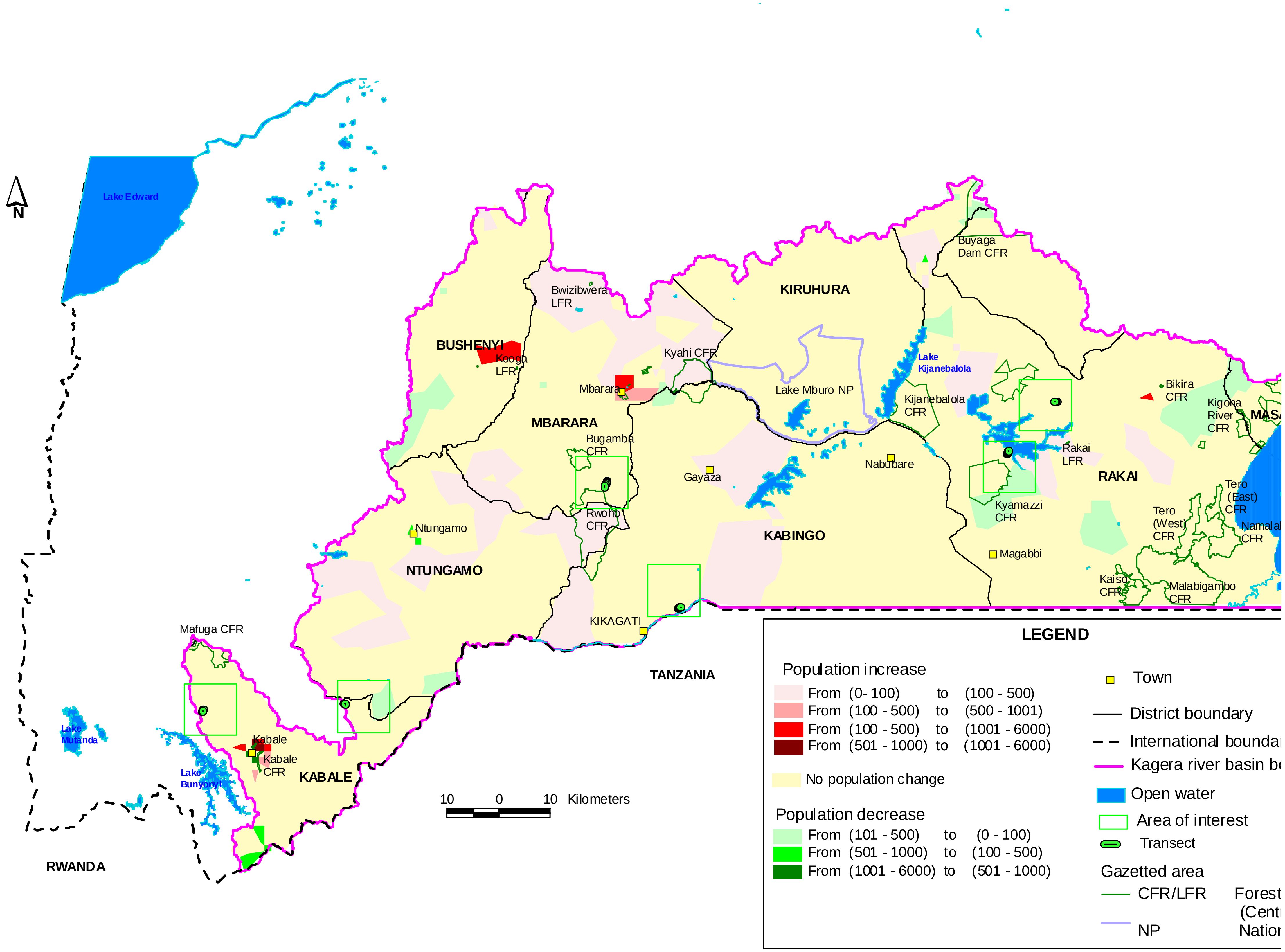



**Figure 46. Areas whose population density more than doubled between 1991 and 2002.**

## 4.0 DETAILED LAND COVER/USE STUDIES ALONG/AROUND SIX TRANSECTS

FAO-TAMP (Uganda team) together with MUIENR Geographic Service staff, selected 6 transect , approximately 1 km long, and undertook rapid surveys of soil properties, land cover, land use, agro forestry, livestock, and other human activities along each transect. In a separate exercise, MUIENR Geographic Service staff carried out a land use/cover change within an area covering 100 $km^2$ around each transect. The preliminary findings of these transect-based studies are presented in this section. They are still preliminary findings because a map derived from aerial photographs (1955) and the FAO Africover data were compared during land use/cover change analysis. While the land cover map (scale 1:50,000) accurately depicts the broad land cover categories of a given area across all Uganda's landscapes, land cover derived from low/coarse resolution imagery do not, as noted in Section 3.6.

### 4.1 The approach

The study approach for the above two exercises were straight forward. First, the Uganda TAMP team made a transect along an agreed direction across a terrain with the Lake Victoria/Kagera Basin in Uganda. A GPS was used to map the transect traversed. As the team move along the transect, a rapid survey of soil properties, land cover, land use, agro forestry, and livestock was conducted. Along each transect, MUIENR Geographic Services' staff was interested in land cover/use and the mapping of the transect itself. The rest of the team collected their own specialty's data. Such specialty's data was analysed and reported elsewhere but using the same terrain cross-section prepared by MUIENR Geographic Services.

Broad land cover/use categories, for 1955, were digitised within 100 $km^2$ of terrain selected around each of the six transects using scanned topographic maps. The use of scanned topographic maps, as a source of historical data, has been used in other projects with good success in Uganda. Figure 47 shows a scanned topographic sheet map (1955) and ASTER (2005) data of the same piece of terrain. The two types of data (scanned topographic map and ASTER data) were used to carry out land cover/use change analysis for an animal corridor in western Uganda. The same techniques of deriving baseline land cover/use information applied in Figure 47 was adopted for the present study. For the present study, however, the piece of terrain mapped using a scanned topographic map was compared with land cover from FAO Africover database. Each of the six FAO's Africover maps, around each transect, was reclassified using the same classification system used on Uganda's topographic maps. This approach allowed us to compare the two land cover maps around each transect, qualitatively and quantitatively.

Last, a cross-section of each transect was generated as follows: The GPS data was downloaded into TNTmips GIS software. Each transect was superimposed on the DEM data depicted in Figure 5, after transforming the DEM layer to standard UTM coordinates. This was done because the GPS used to map each transect was confirmed in UTM map projections for Uganda. After zooming in around each transect vector line superimposed on the DEM data, a line was traced over each line transect. A cross-section, for each transect was then automatically generated by the TNTmips software and then saved as a separate file (CAD file) and eventually imported into a word processor. Each cross-section depicted, on actual cartographic scale, the altitude and horizontal distance of each transect. All the land use types, and other general information, were then included on the relevant part of each transect. The findings related to each transect are presented in Figures 48 – 59 and Tables 6 – 11. A text callout provides an interpretation of the findings of each transect.

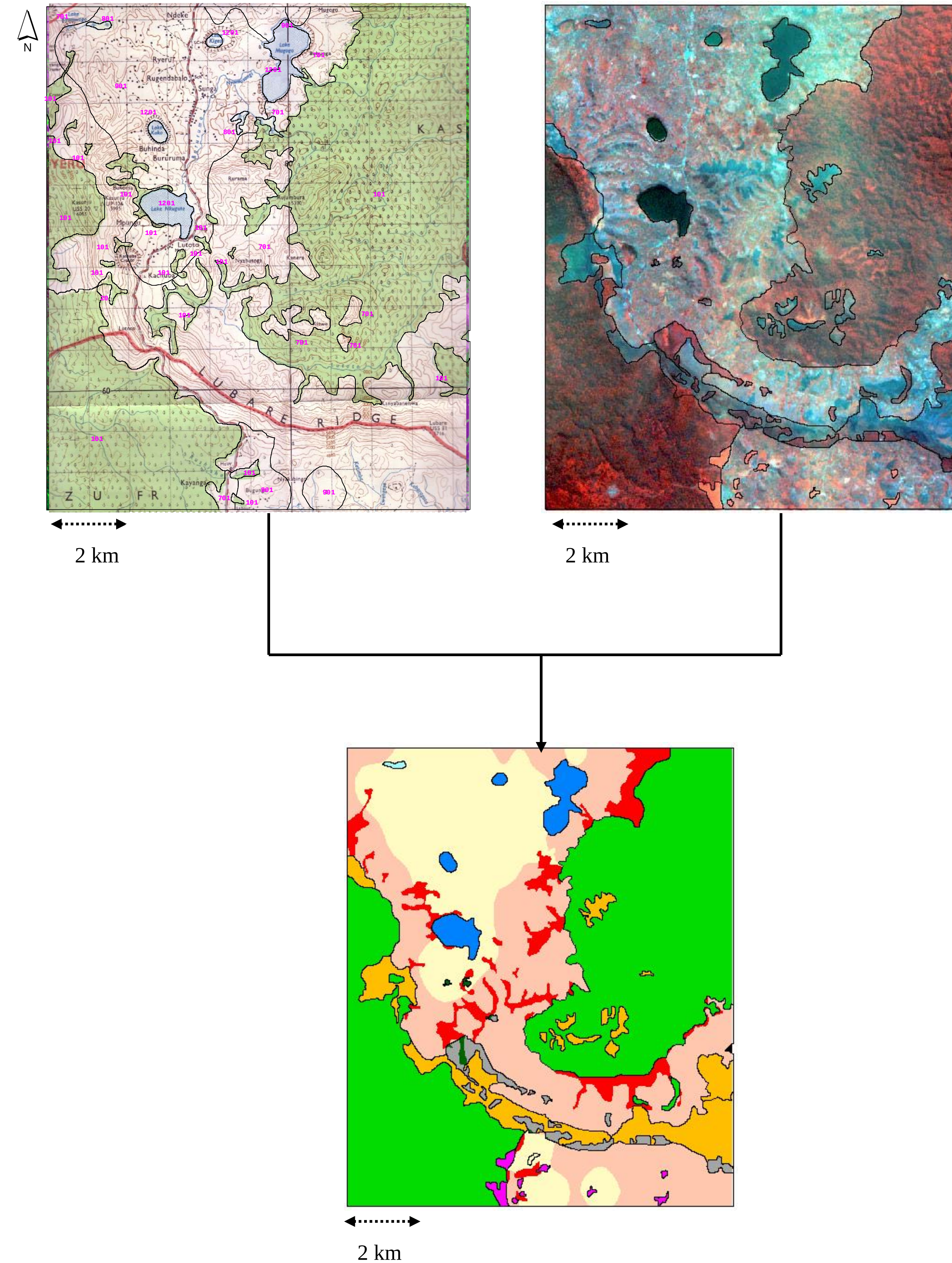
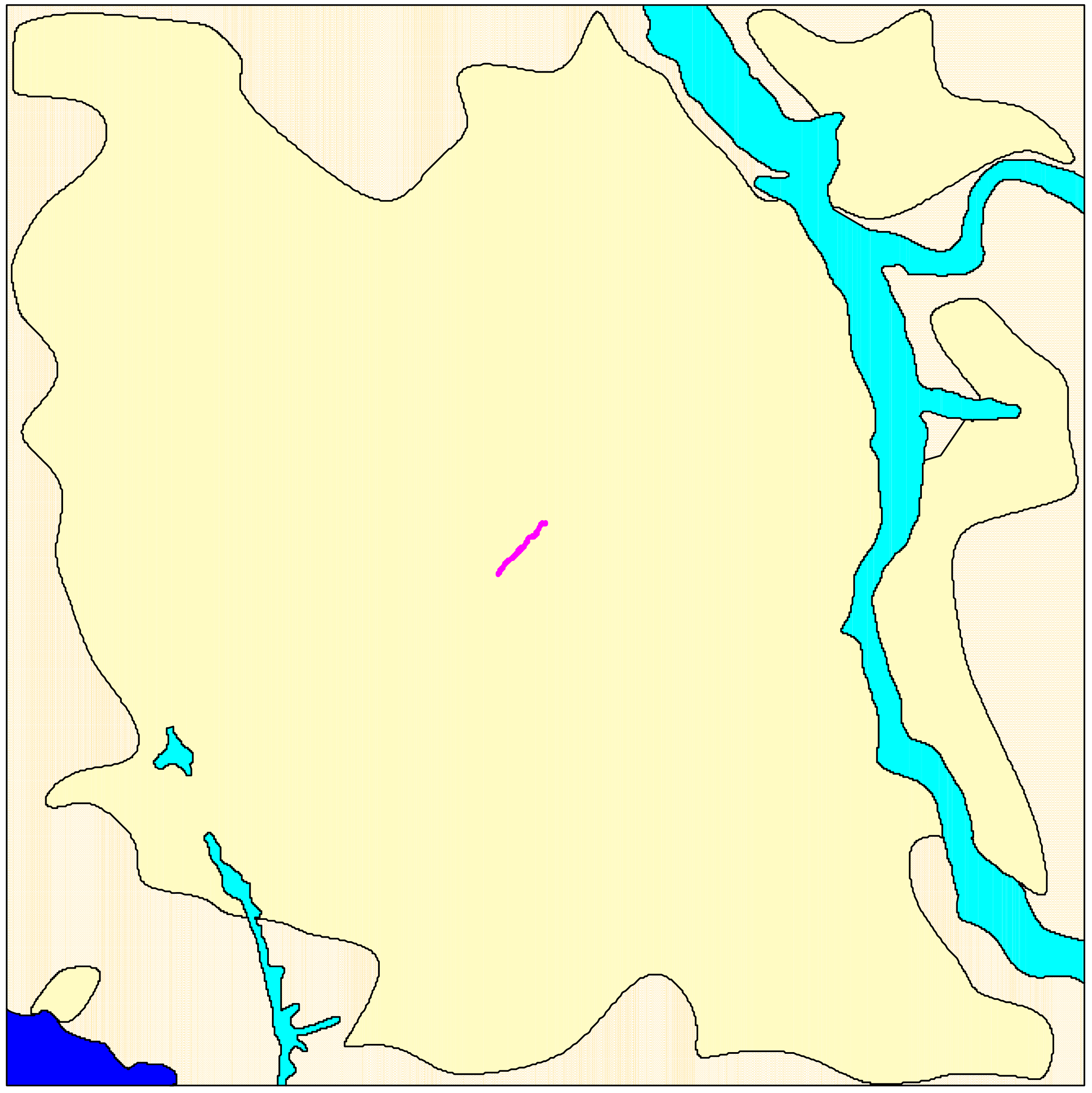
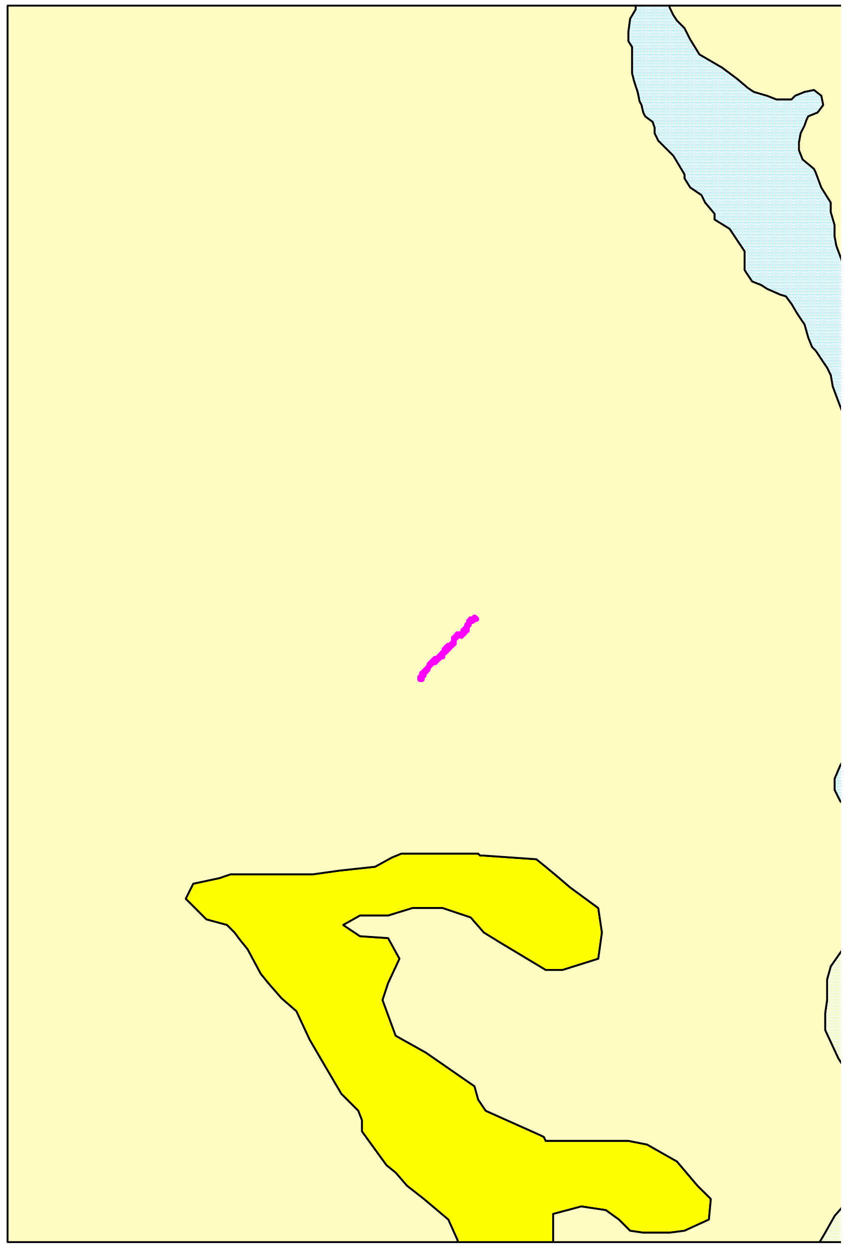



**Figure 47. Land cover/use changes from forests to cultivation (red colour), savanna grassland to cultivation (pink colour), savanna grassland to Eucalyptus (grey colour) can be derived from scanned topographic maps and then the baseline (1955) compared with recent land cover maps (e.g. from ASTER or Landsat TM).**

**FIGURE 48 (KABALE DISTRICT): SITE 1 SHOWING THE LOCATION OF TRANSECT 1 (SUPERIMPOSED ON 1955 AND 2002 LAND USE/COVER DATA)**



**Area of interest 1 (Kabale): Land use/cover (1955)**
- Grassland with sparse trees
- Wetland
- Subsistence farming
- Water
- Transect 1 (Bubare, Kabale)



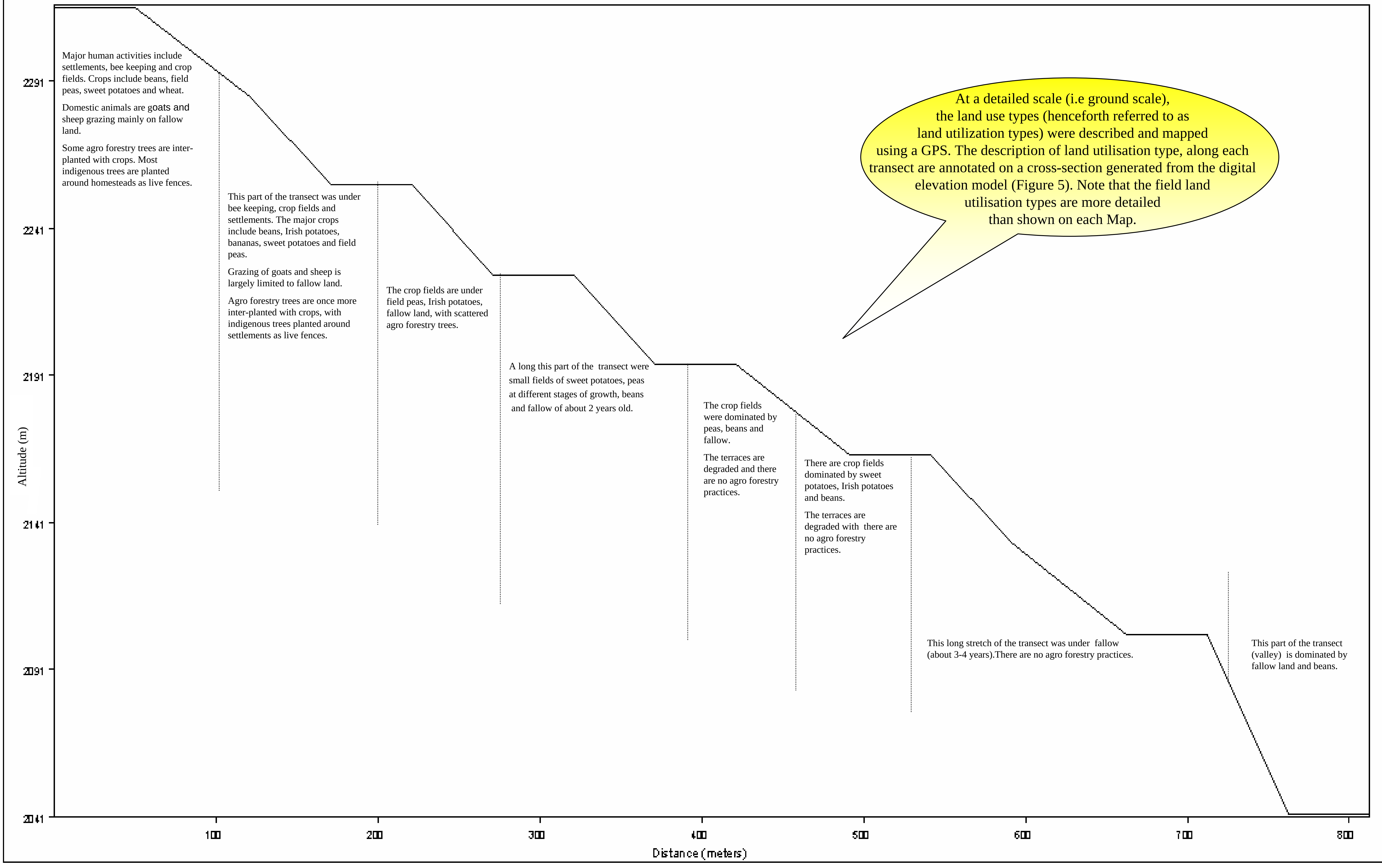
**Area of interest 1 (Kabale): Land use/cover (2002)**
- Open shrubs/herbaceous
- Open shrubs/herbaceous (seasonal flooded)
- Subsistence farming
- Subsistance farming/woodlots
- Transect 1 (Bubare, Kabale)

**Table 6. Land cover/use change analysis (1955 and 2002) for site 1 (Kabale District).**

| Land use/cover | Year 1955 (Km²) | 1955 % | 2002 (km²) | 2002 % | Land use change (km²) | Land use change (%) |
|---|---|---|---|---|---|---|
| Open shrubs/herbaceous | 0 | 0 | 3.4 | 3.35 | 3.4 | |
| Open shrubs/herbaceous/(seasonal flooded) | 0 | 0 | 7.85 | 7.74 | 7.85 | |
| Grassland | 24.31 | 24 | 0 | | -24.31 | -100.0 |
| Wetland | 5.59 | 5.5 | 0 | | -5.59 | -100.0 |
| Subsistence Farming | 70.82 | 69.8 | 80.18 | 79.19 | 9.36 | 13.2 |
| Subsistence Farming/woodlots | 0 | 0 | 9.94 | 9.8 | 9.94 | |
| Water | 0.67 | 0.7 | | | -0.67 | -100 |
| **Total** | **101.39** | **100** | **101.37** | **100** | | |

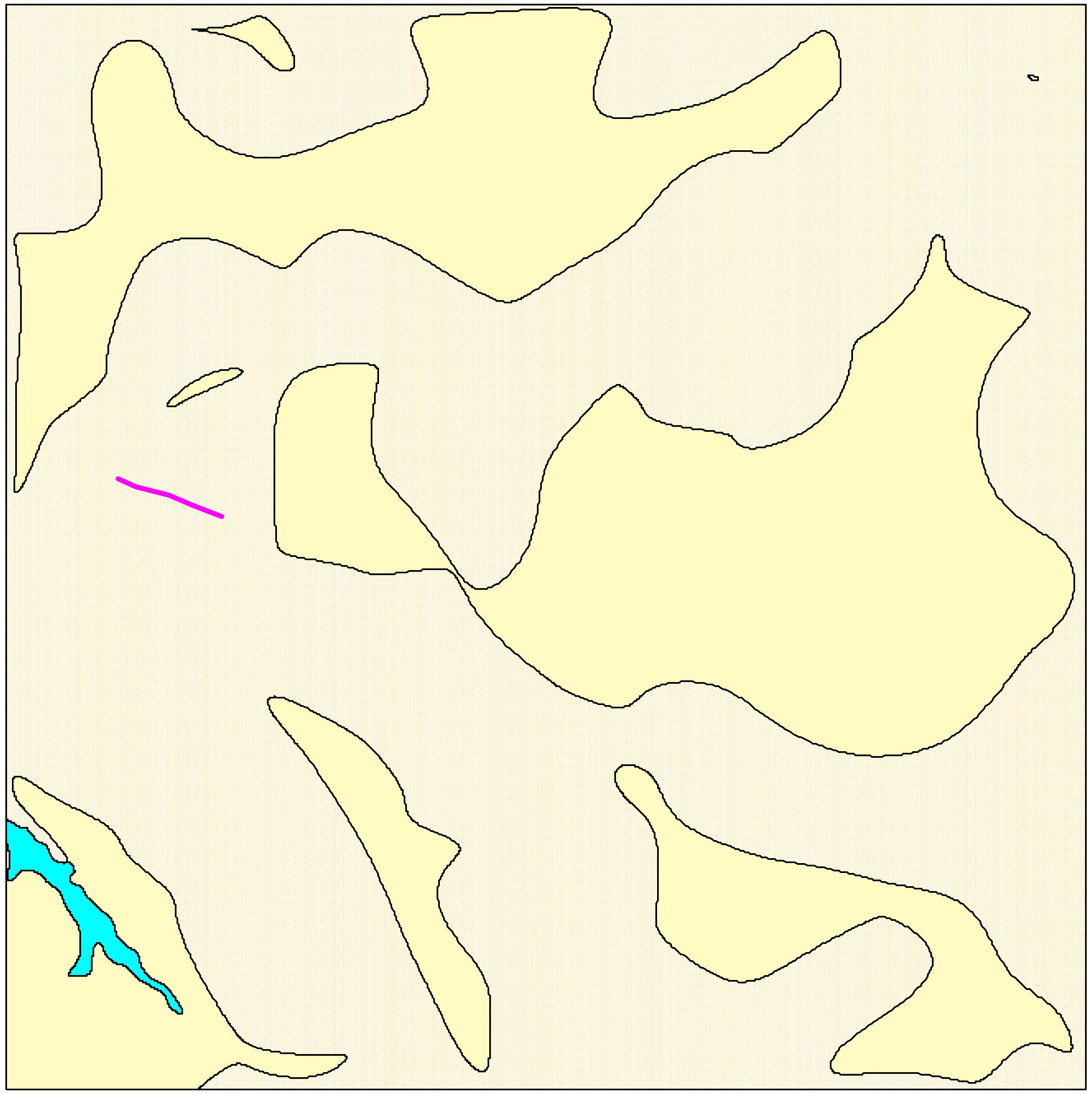
Owing to the enormous size of the Kagera River Basin (Uganda), it was not possible to carry out a land use change analysis in the whole region. However, a detailed diagnostic study has been conducted along six transects, selected in the whole region. Along each transect, a detailed description of land utilisation types have been conducted. In the maps above, it is indicated that the location of the transect was characterised by cultivated land both in 1955 and 2002. The table on the left shows how land use has changed over the last 50 years in the area of interest (approx. 100 sq. km).

**FIGURE 49 (KABALE DISTRICT): LAND UTILISATION TYPES ALONG TRANSECT 1**



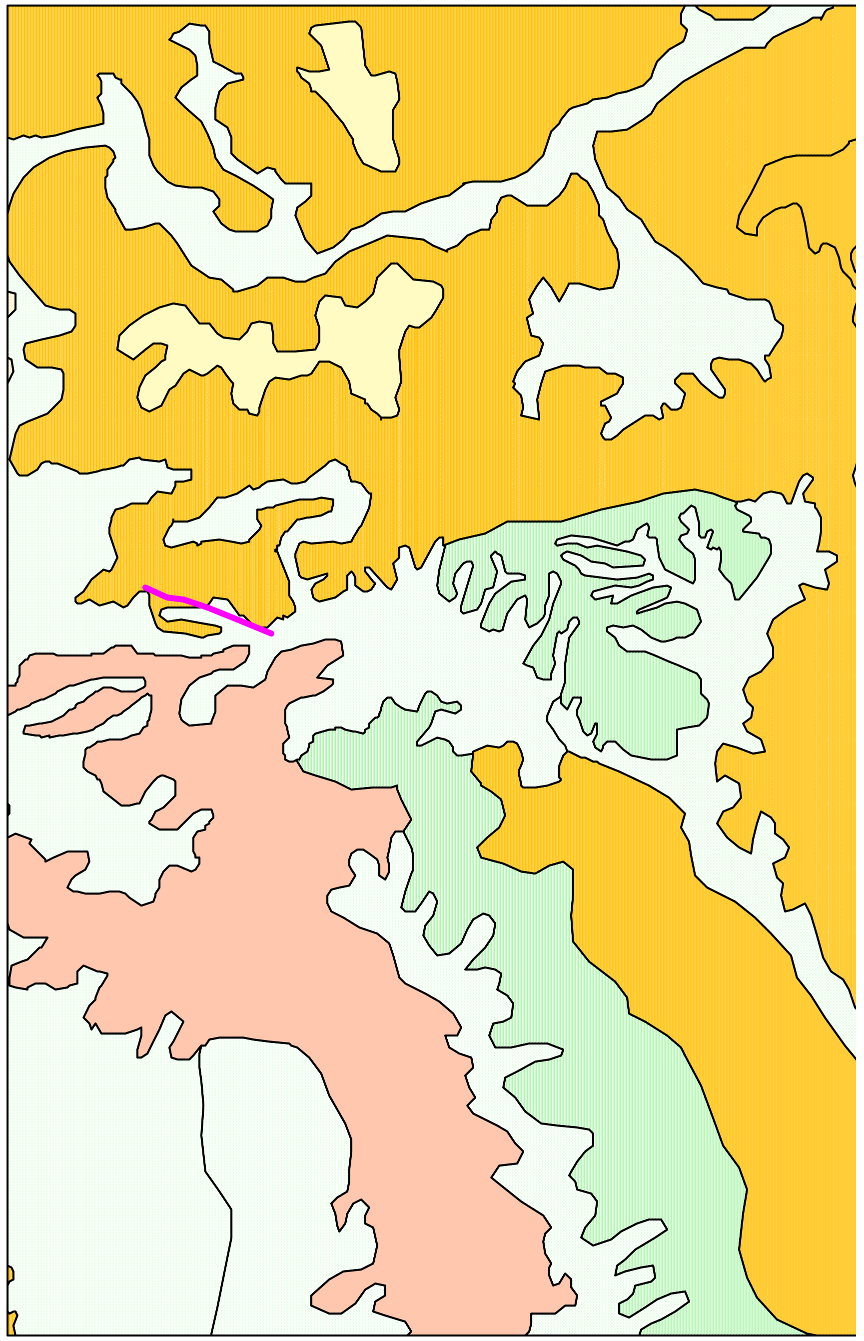

Note: For the entire transect, the health of the crops implies that the soils have lost their nutrients and they are poorly managed; the major weeds found were are *couch* grass, *black jack, goat weed, thorn apple and gallant soldier* and *Mexican marigold*.

## FIGURE 50 (KABALE DISTRICT): SITE 2 SHOWING THE LOCATION OF TRANSECT 2 (SUPERIMPOSED ON 1955 AND 2002 LAND USE/COVER DATA)



**Area of interest 2 (Kabale): Land use/cover (1955)**

- Grassland with sparse trees
- Wetlands
- Subsistence farming
- Transect 2 (Kamwezi, Kabale District)

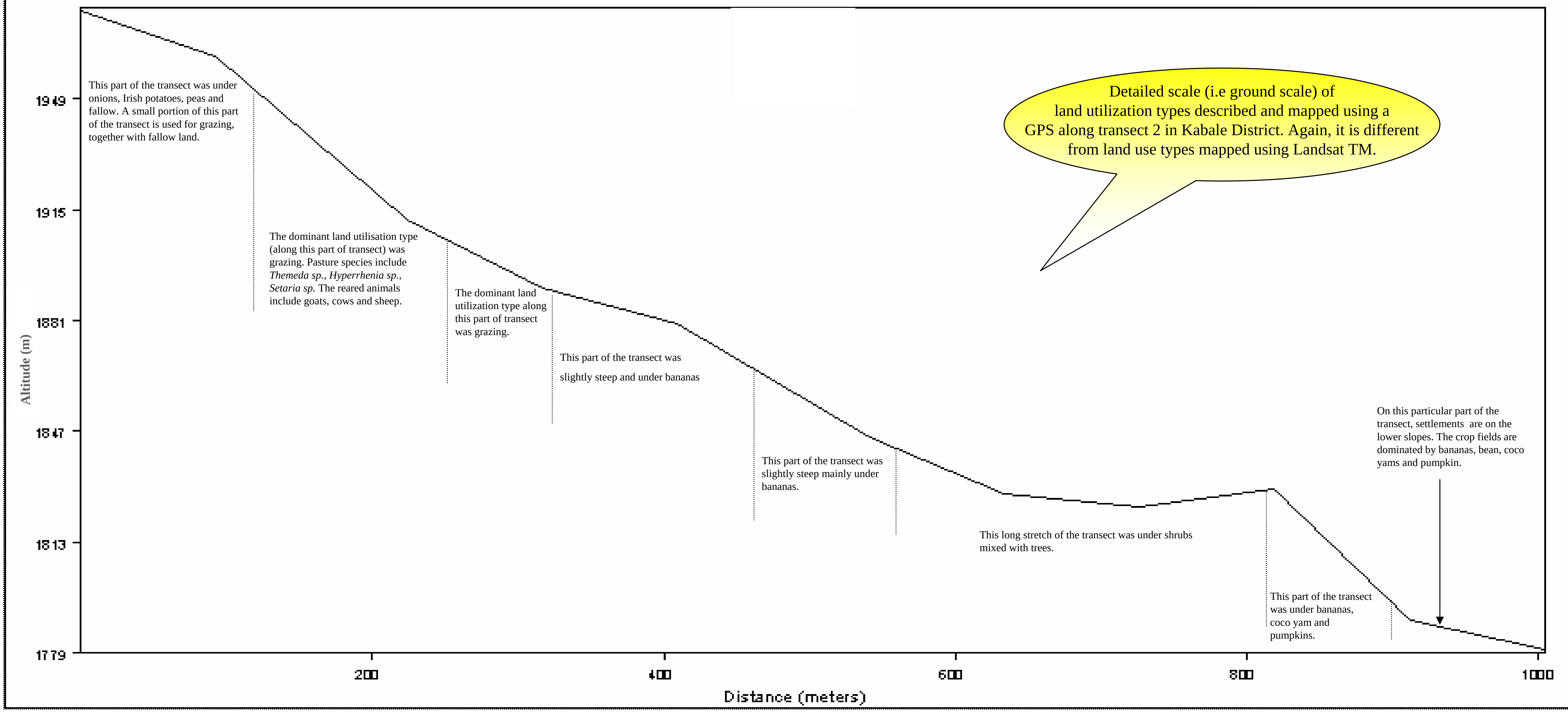


In the 1950s, transect 2 (Kabale District) was along a piece of land that was not cultivated at all. Even though the Africover map shows that the land along the transect is still natural, ground surveys using a GPS show that most of the land along the transect is under crops or pasture. The findings may be wrong due to propagated errors.

**Table 7. Land cover/use change analysis (1955 and 2002) for site 2 (Kabale District).**

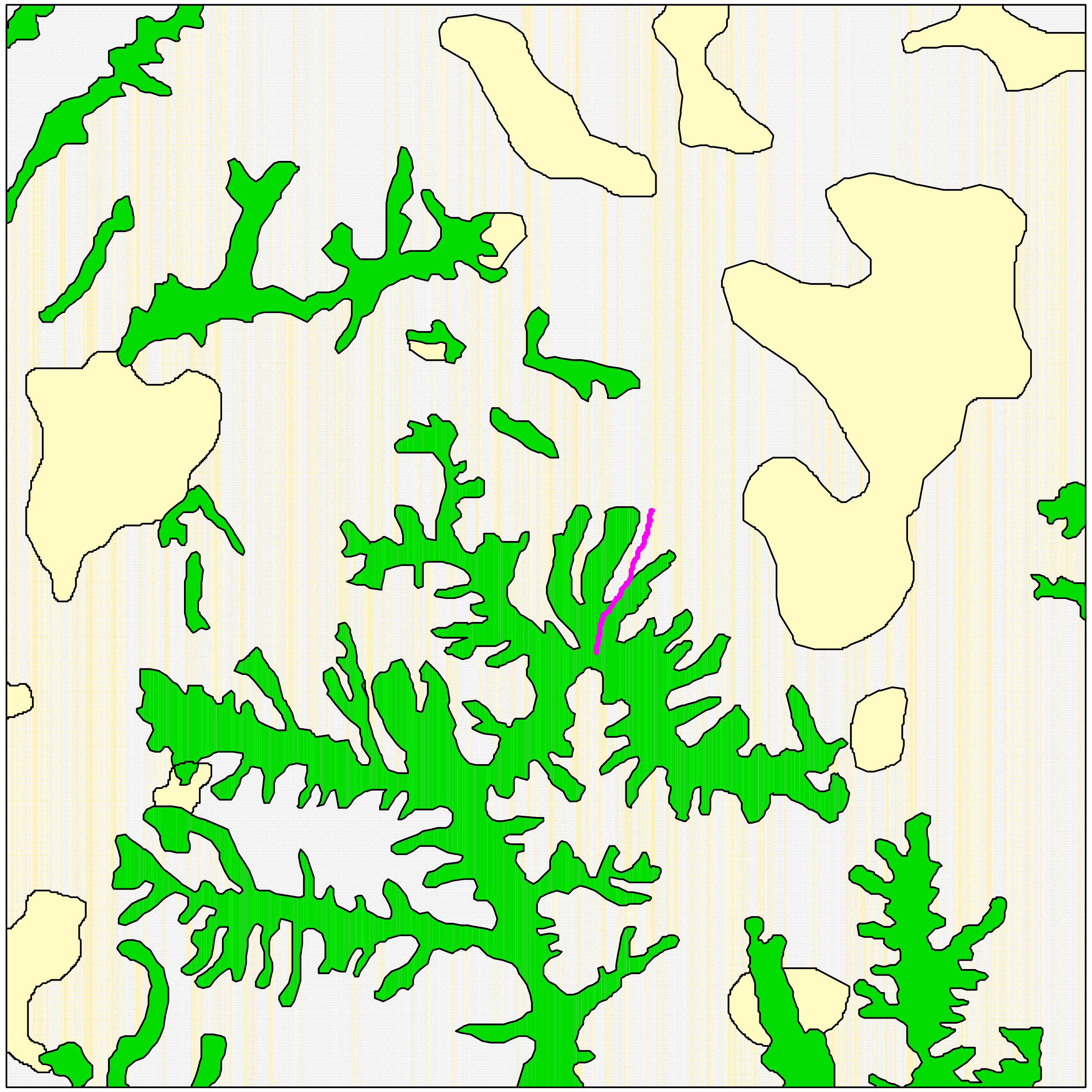
| Land use/cover | Year | | | | Land use change (km²) | Land use change (%) |
|---|---|---|---|---|---|---|
| | 1955 | | 2002 | | | |
| | Km² | % | Km² | % | | |
| Closed Grassland | | | 0.02 | 0.02 | 0.02 | |
| Closed Grassland/sparse trees | | | 42.75 | 41.75 | 42.75 | |
| Grassland | 63.13 | 62.3 | | | -63.13 | -100.0 |
| Open shrubs/herbaceous | | | 8.91 | 8.7 | 8.91 | |
| Open shrubs/herbaceous/sparse trees | | | 11.14 | 10.88 | 11.14 | |
| Open shrubs/herbaceous/sparse trees/flooded | | | 1.16 | 1.13 | 1.16 | |
| Wetland | 0.52 | 0.5 | | | -0.52 | -100.0 |
| Small shrub/rainfed | | | 36.78 | 35.92 | 36.78 | |
| Subsistence Farming | 37.73 | 37.2 | 1.63 | 1.59 | **-36.1** | -95.7 |
| **Total** | **101.38** | **100** | **102.39** | **100** | | |

**FIGURE 51. KABALE DISTRICT: LAND UTILISATION TYPES ALONG TRANSECT 2**



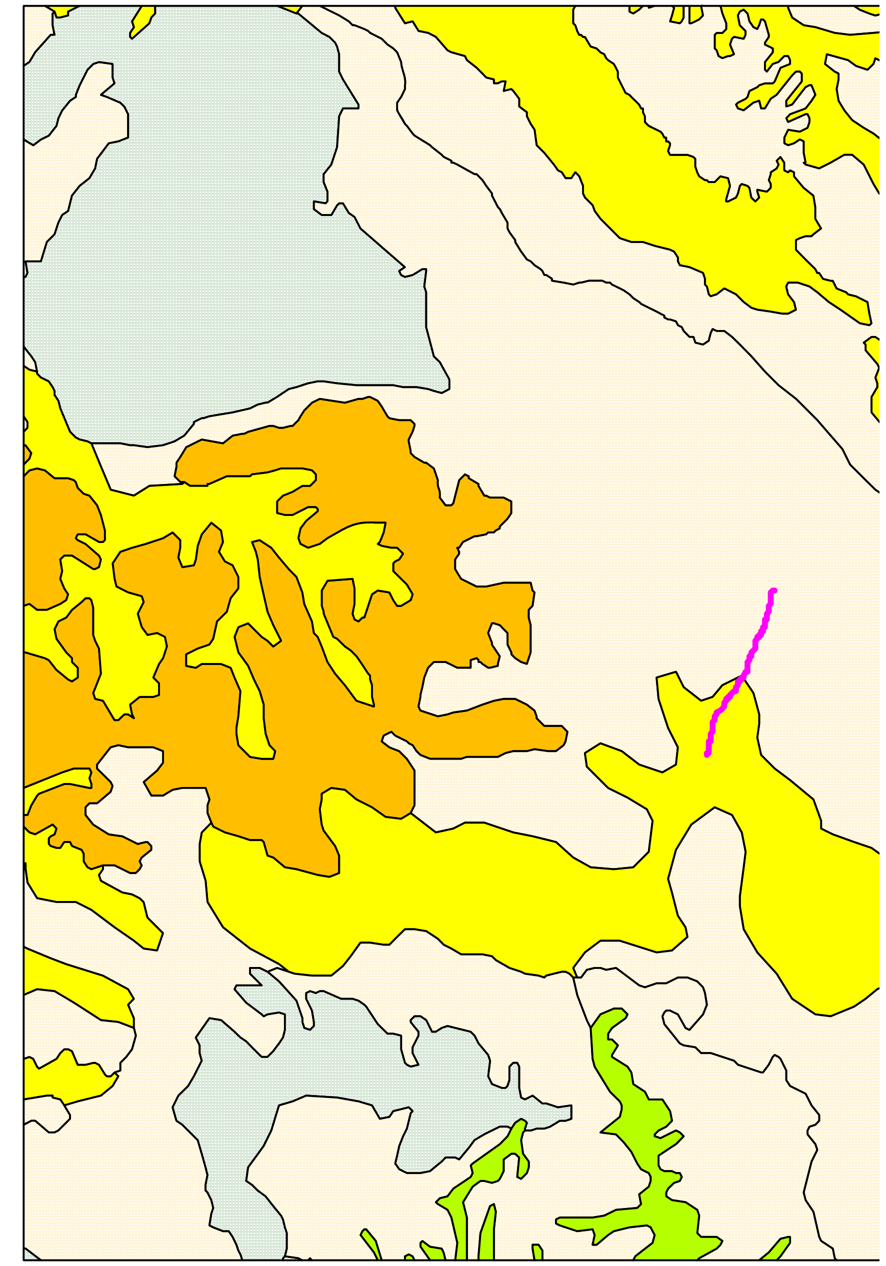

**Note**: -The crop fields are bigger than is the case for transect 1. A variety of weeds were found along this transect: the Black jack, Gallant soldier, Goat weed and *leonolis* and *Oxalis spp*. There are many scattered shrubs (dominated by Dodonia) mixed with grass along the transect.. There are indications of land degradation (bare land) due to grazing especially on on hill tops.

**FIGURE 52. MBARARA DISTRICT: SITE 3 SHOWING THE LOCATION OF TRANSECT 3 (SUPERIMPOSED ON 1955 AND 2002 LAND USE/COVER DATA)**



**Area of interest 3 (Mbarara): Land use/cover (1955)**

- Forest
- Grassland with sparse trees
- Wetland
- Grassland (seasonally flooded)
- Subsistence farming
- Transect 3 (Mwizi, Mbarara District)



**Area of inte**

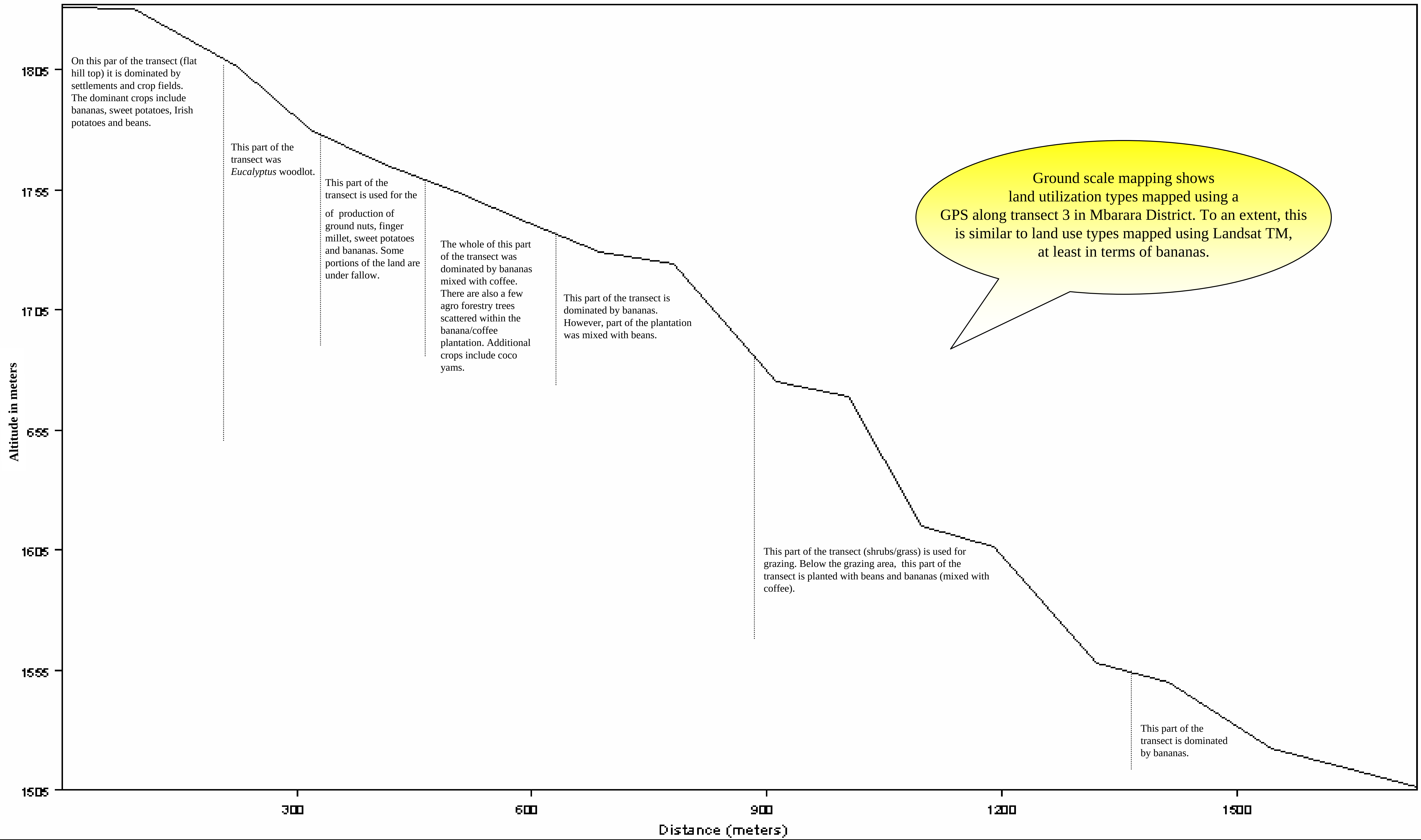
- Closed
- Grassla
- Open t
- Subsis
- Forest
- Transe

In the 1950s, transect 3 (Mbarara District) was along a piece of land under the cover of natural vegetation (forest and grassland). Today, the transect is along bananas and seasonal crops, according the map above.

| Land use/cover | Year | | | | Land use change (km²) | Land use change (%) |
|---|---|---|---|---|---|---|
| | 1955 | | 2002 | | | |
| | Area (km²) | % | Area (km²) | % | | |
| Forest | 18 | 17.8 | 0 | 0 | -18.0 | -100.0 |
| Open trees/herbaceous (seasonally flooded) | | | 1.02 | 1.0 | 1.0 | |
| Forest plantations (soft wood) | | | 11 | 10.9 | 10.9 | |
| Grassland with scattered trees | 69.34 | 68.4 | 65.92 | 65.0 | -4.3 | -6.2 |
| Subsistence farming - bananas | 14.06 | 13.9 | 23.44 | 23.1 | 9.1 | |
| **Total** | **101.4** | **100.0** | **101.38** | **100.0** | | |

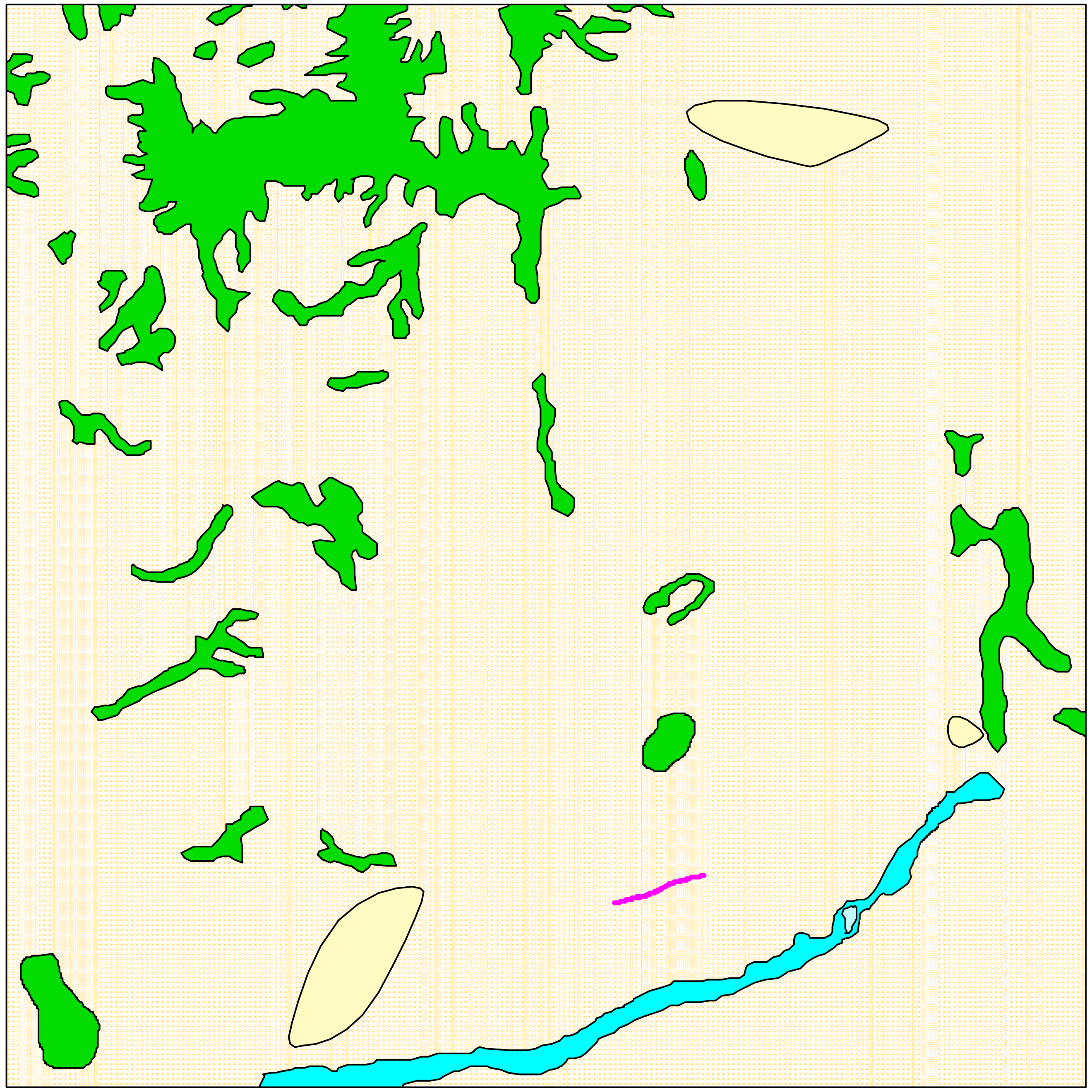
**Table 8. Land cover/use change analysis (1955 and 2002) for site 3 (Mbarara District).**

**FIGURE 53. MBARARA DISTRICT : LAND UTILISATION TYPES ALONG TRANSECT 3**




**Note**: The dominant weeds include Black jack,Goat weed, Couch grass, Star grass, Gallant soldier and Mexican Marigold.

**FIGURE 54. KABINGO DISTRICT: SITE 4 SHOWING THE LOCATION OF TRANSECT 4 (SUPERIMPOSED ON 1955 AND 2002 LAND USE/COVER DATA)**



**Area of interest 4 (Kabingo): Land use/cover (1955)**

- Forest
- Grassland with sparse trees
- Wetland
- Grassland with sparse trees (seasonally flooded)
- Subsistence farming
- Transect 4 (Ruyanga, Kabingo District)

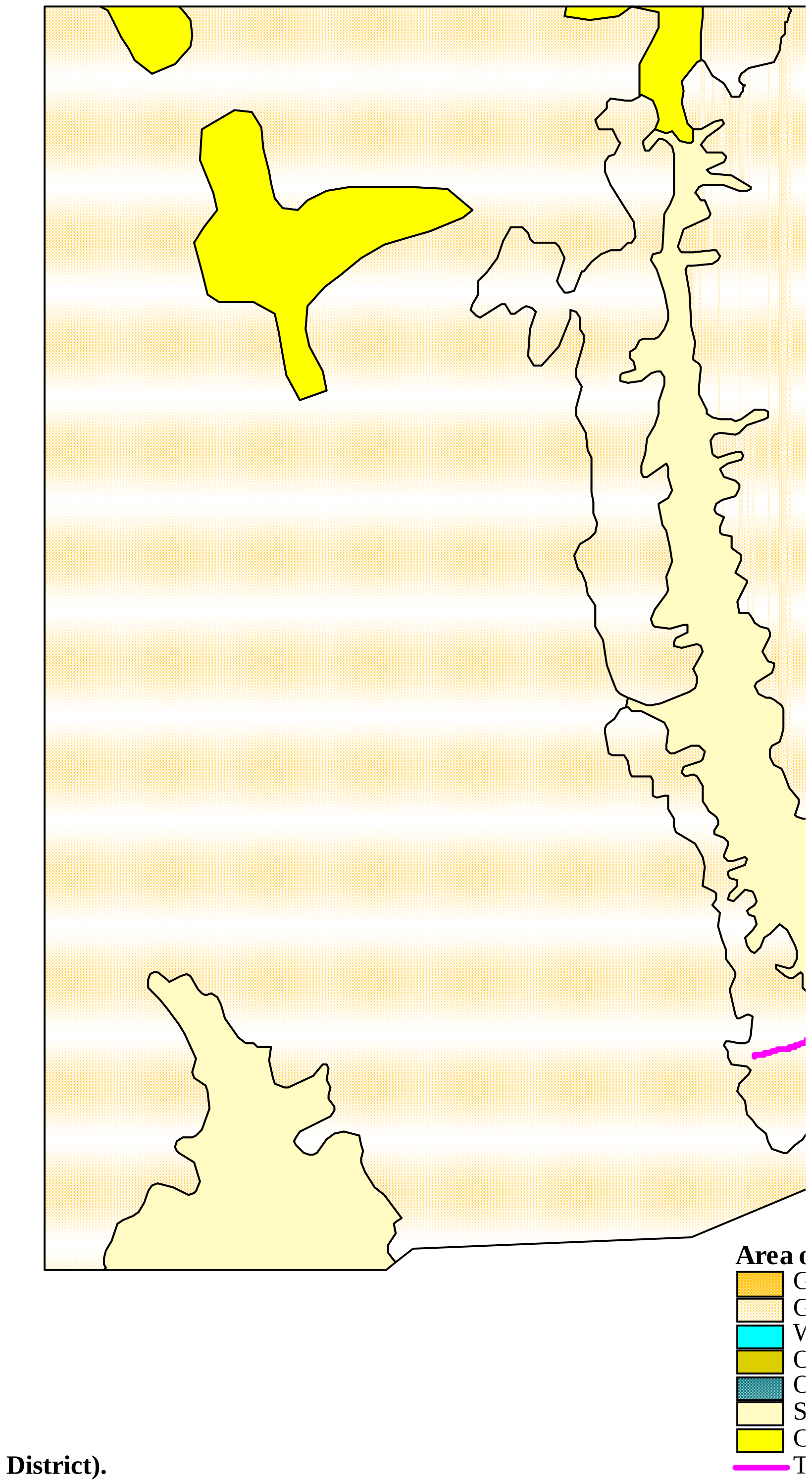
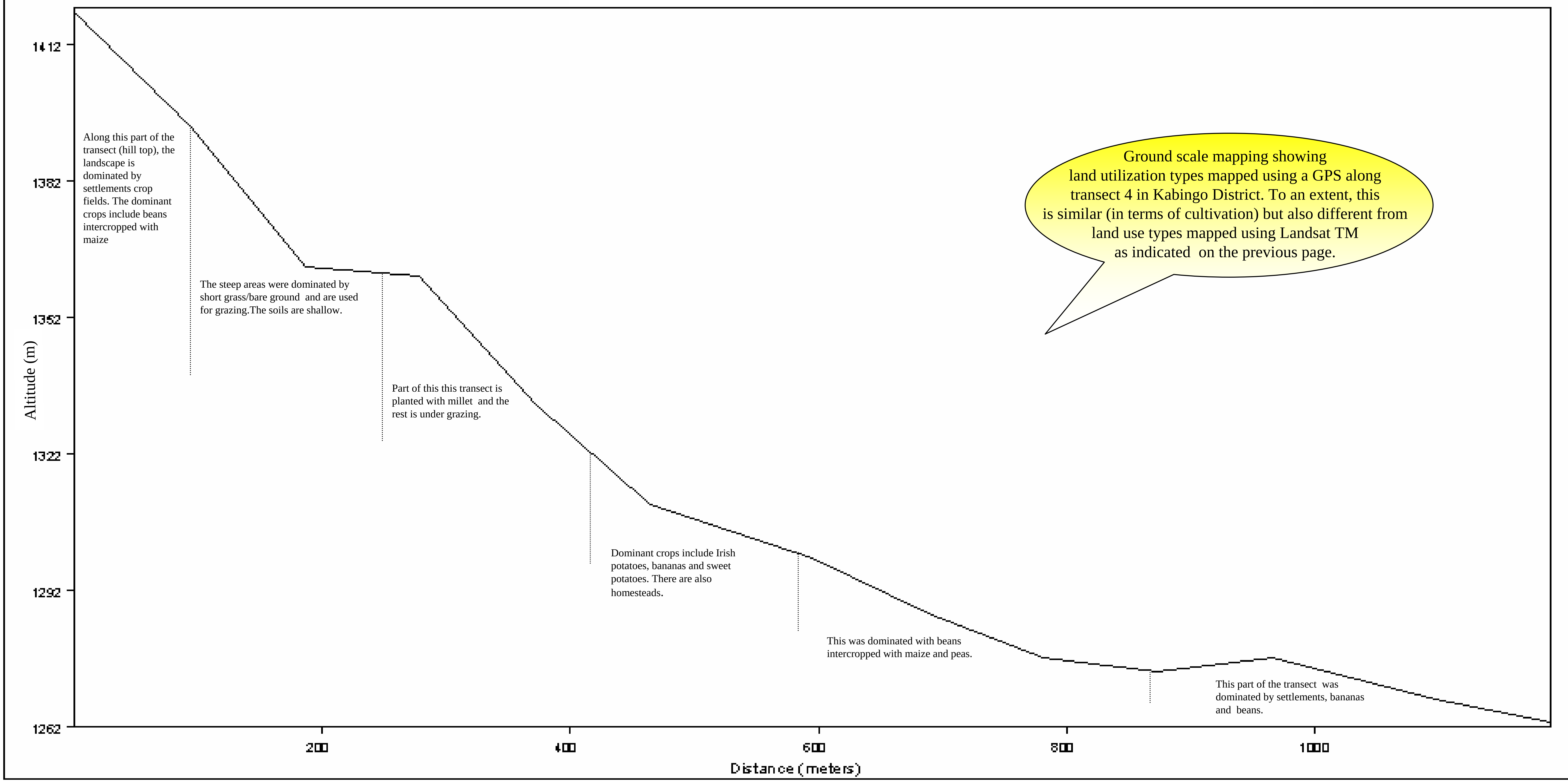



**Table 9. Land cover/use change analysis (1955 and 2002) for site 4 (Kabingo District).**

| Land use/cover | Year | | | | Land use change (km²) | Land use change (%) |
|---|---|---|---|---|---|---|
| | 1955 | | 2002 | | | |
| | Area (Km²) | % | Area (km²) | % | | |
| Forest | 9.2 | 9.1 | 0 | | -9.2 | -100.0 |
| Open trees/herbaceous (seasonally flooded) | | | 0.45 | 0.4 | 0.4 | 98.6 |
| Open shrubs/herbaceous (seasonally flooded) | | | 0.53 | 0.5 | 0.5 | |
| Grassland with scattered trees | 89.03 | 87.8 | 84.7 | 83.6 | -5.5 | -6.2 |
| Wetland | 1.42 | 1.4 | 0.023 | 0.0 | -1.4 | -98.4 |
| Subsistence farming | 1.73 | 1.7 | 13.23 | 13.1 | 11.5 | 664.7 |
| Subsistence farming-bananas | | | 2.44 | 2.4 | 2.4 | |
| **Total** | **101.38** | **100.0** | **101.373** | **100.0** | | |

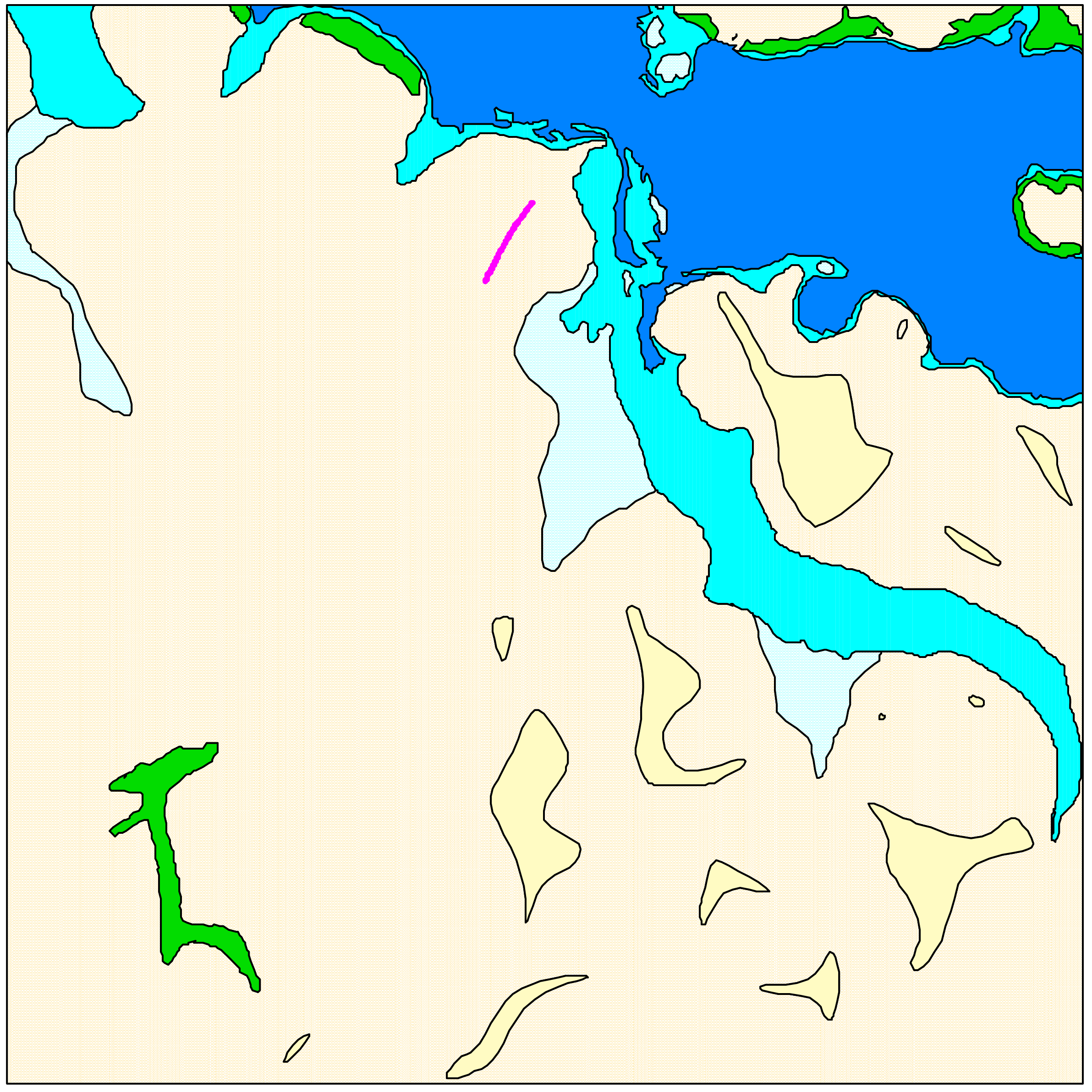
In the 1950s, transect 4 (Kabingo District) was a long a piece of land that was under the cover of natural vegetation (grassland). Today, the transect is under the cover of seasonal crops and follow as indicated on the next page.

FIGURE 55. KABINGO DISTRICT: LAND UTILISATION TYPES ALONG TRANSECT 4



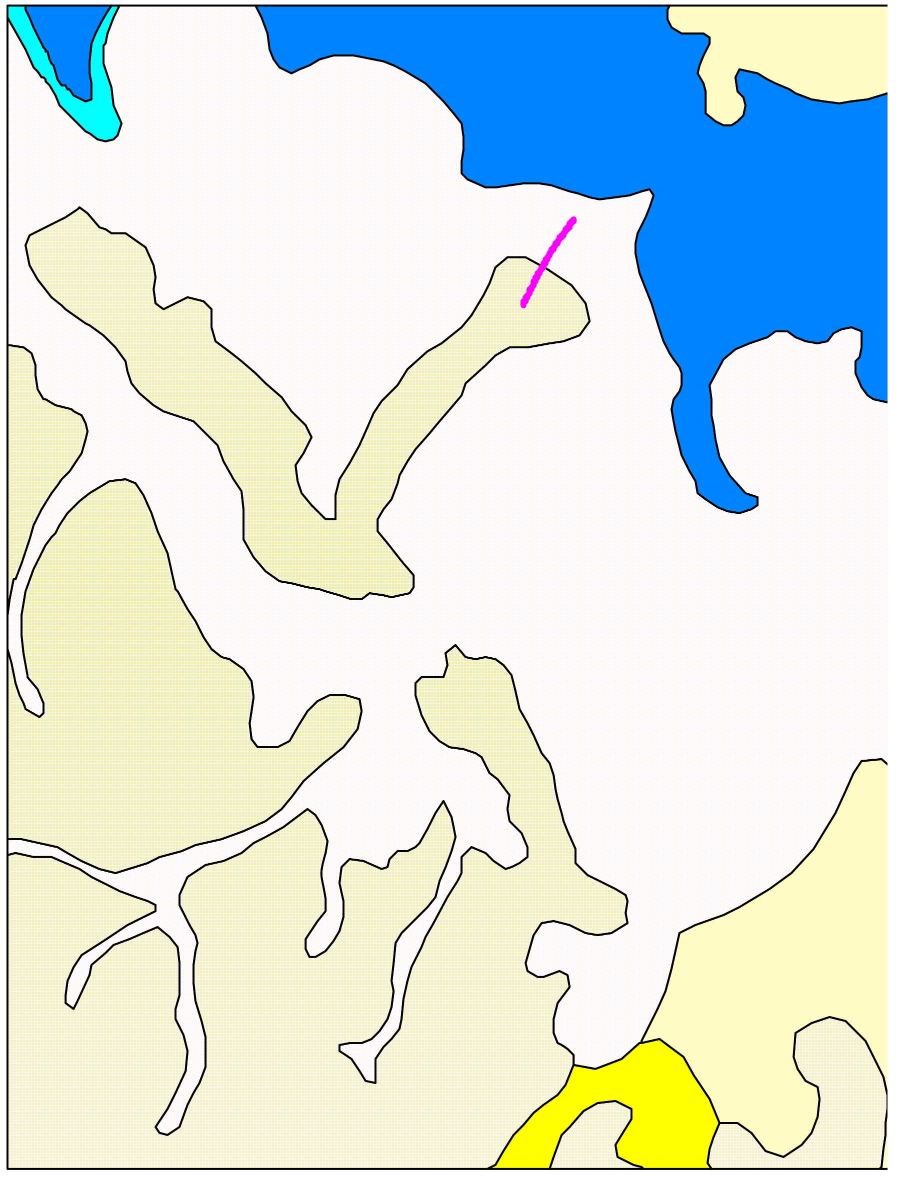

**Note:** -The dominant weeds a long this transect were Black jack, Goat weed, Couch grass, Euphobia and Gallant soldier. A long the entire transect, there were a few agro forestry trees. A few indigenous trees and shrubs and fruit trees are planted near homesteads.

**FIGURE 56. RAKAI DISTRICT: SITE 5 SHOWING THE LOCATION OF TRANSECT 5 (SUPERIMPOSED ON 1955 AND 2002 LAND USE/COVER DATA)**



**Area of interest 5 (Rakai): Land use/cover (1955)**

- Forest
- Grassland with sparse trees
- Wetland
- Grass/shrubs with seasonal trees
- Grass/shrubs (seasonal wetland)
- Subsistence farming
- Water
- Transect 5 (Kyaruragira, Rakai District)



**Area of interest 5 (Rakai): Land use/cover (**

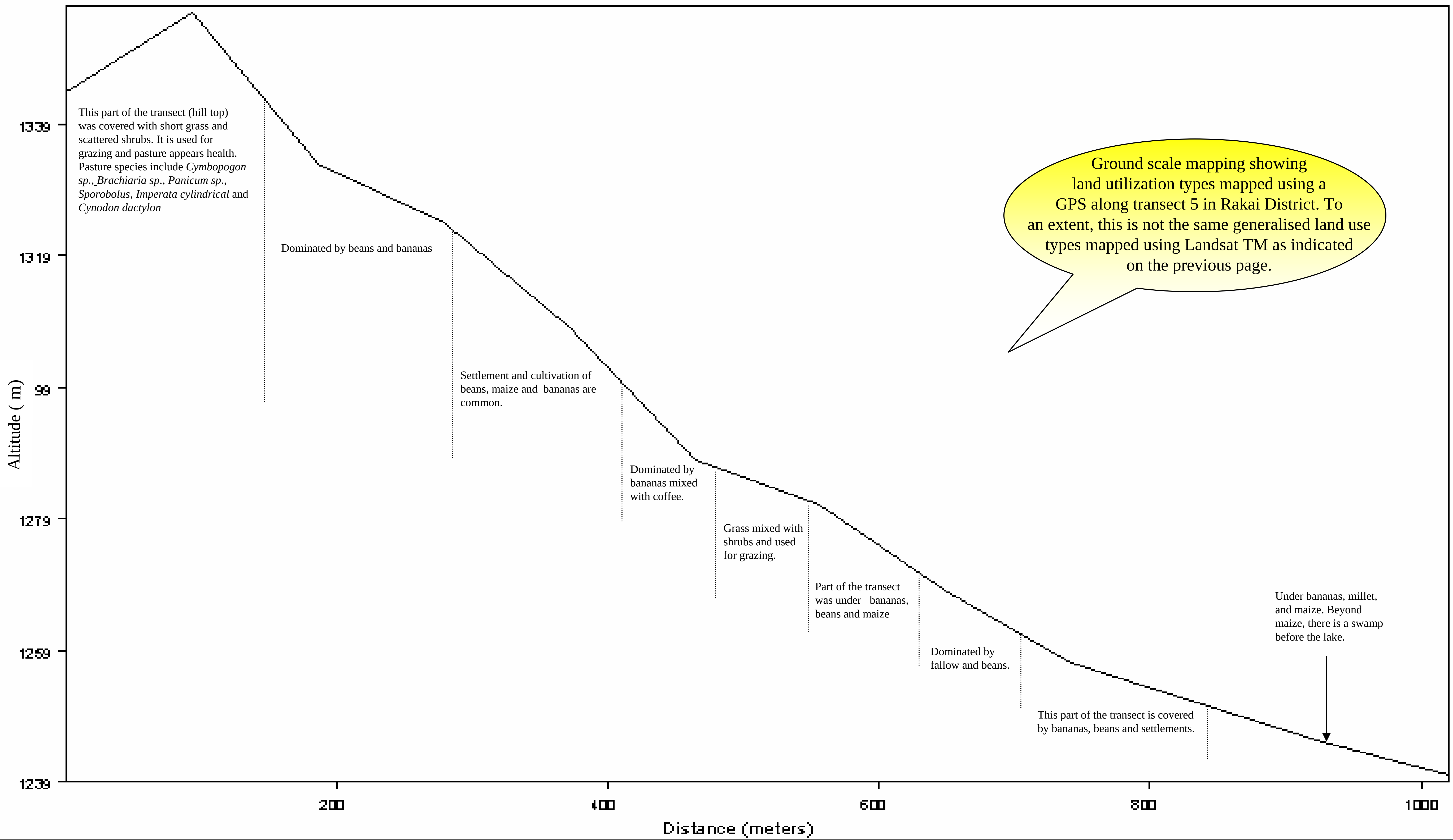
- Grassland with sparse trees
- Grassland with open shrubs
- Wetland
- Water
- Subsistence farming
- Subsistence farming - banana
- Transect 5 (Kyaruragira, Rakai District)

**Table 10. Land cover/use change analysis (1955 and 2002) for site 5 (Rakai District).**

| Land use/cover | Year | | | | Land use change (km²) | Land use change (%) |
|---|---|---|---|---|---|---|
| | 1955 | | 2002 | | | |
| | Area (km²) | % | Area (km²) | % | | |
| Forest | 1.61 | 1.6 | 0 | | -1.6 | -100.0 |
| Grassland with scattered trees | 72.52 | 71.5 | 25.96 | 25.6 | -46.6 | -64.2 |
| Grassland with open shrubs | | | 45.65 | 45.0 | 45.7 | |
| Wetland | 7.26 | 7.2 | 0.36 | 0.4 | -6.9 | -95.0 |
| Grassland with scattered trees (seasonally flooded) | 3.26 | 3.2 | | | -3.3 | -100.0 |
| Subsistence farming | 4.16 | 4.1 | 12.25 | 12.1 | 8.1 | 194.5 |
| Subsistence farming - bananas | | | 1.16 | 1.1 | 1.2 | |
| Water | 12.55 | 12.4 | 16 | 15.8 | 3.5 | 27.5 |
| **Total** | **101.36** | **100.0** | **101.38** | **100.0** | **0.0** | |

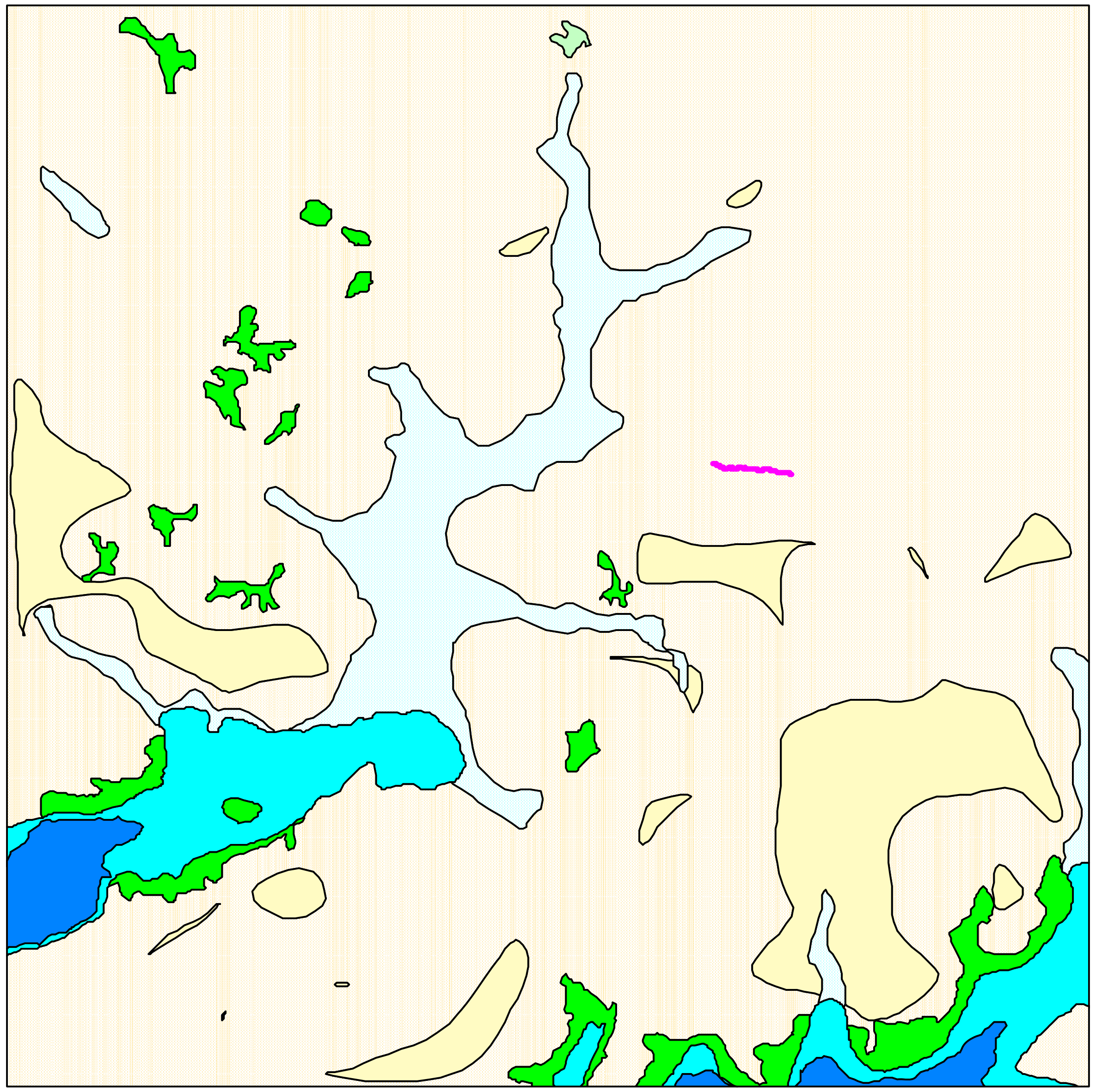
In the 1950s, transect 5 (Rakai District) was covered by natural vegetation (grassland). Today, the transect is under the cover of seasonal crops (see next page) but not as indicated on the map generated from Landsat TM.

**FIGURE 57. RAKAI DISTRICT: LAND UTILISATION TYPES ALONG TRANSECT 5**




**Note:** Part of the transect had shrubs dominated by Acacia's, towards the water edge. The area is densely populated and hence heavily cultivated. The dominant weeds a long the entire transect are Black jack, Couch grass, Gallant soldier, *L eonotis*, Cyprus spp., Senecio and Oxalis.

**FIGURE 58. RAKAI DSTRICT: SITE 6 SHOWING THE LOCATION OF TRANSECT 6 (SUPERIMPOSED ON 1955 AND 2002 LAND USE/COVER DATA)**



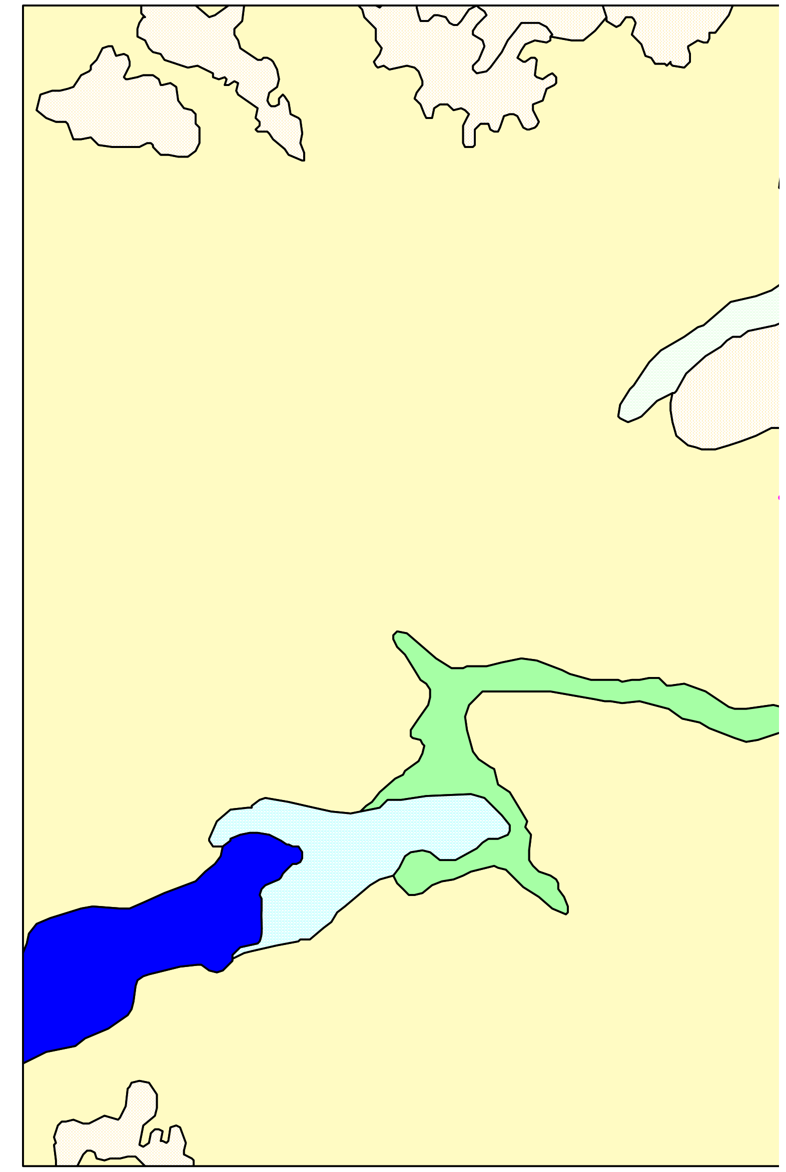
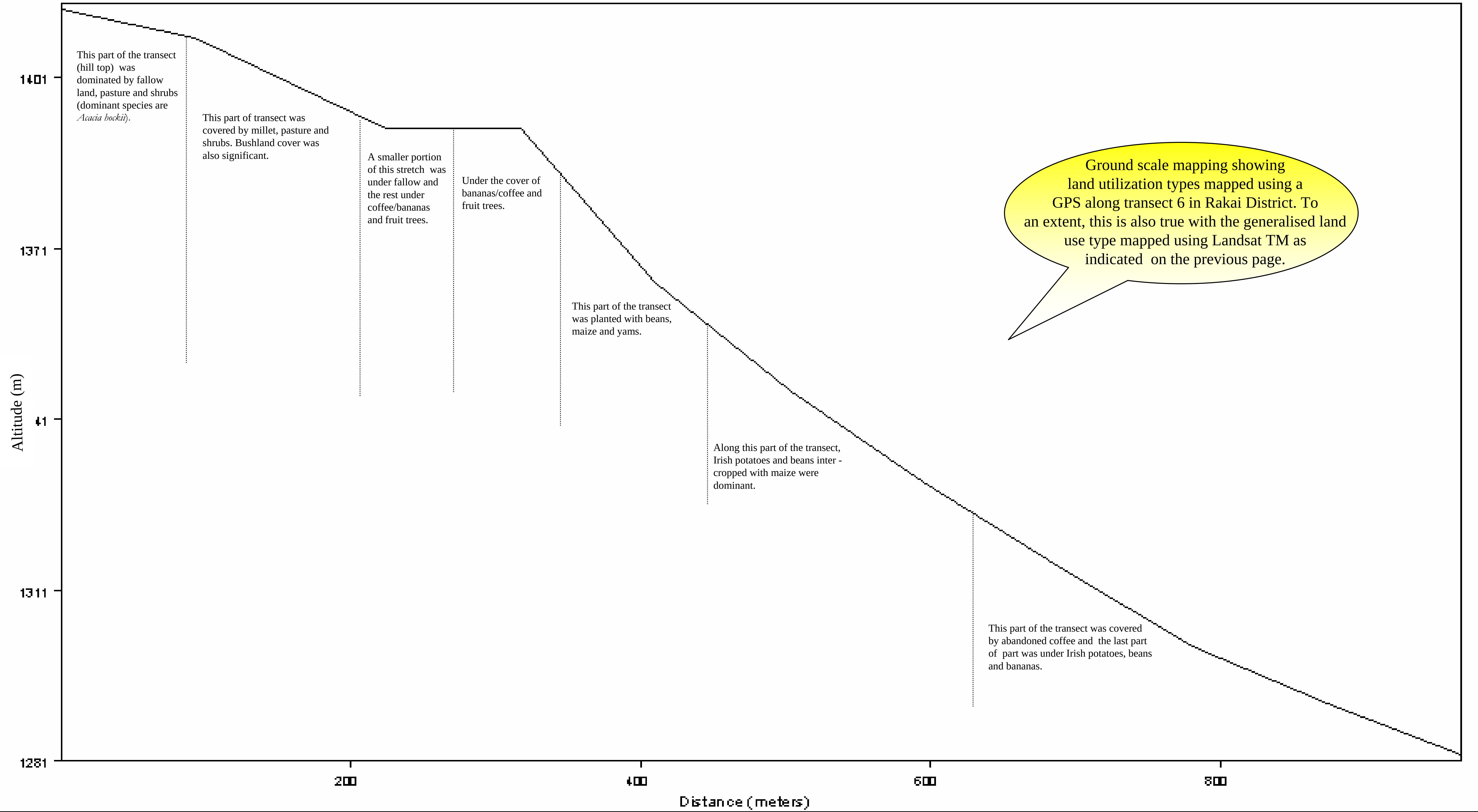




**Table 11. Land cover/use change analysis (1955 and 2002) for site 6 (Rakai District).**

| Land use/cover | Year | | | | Land use change (km²) | Land use change (%) |
|---|---|---|---|---|---|---|
| | 1955 | | 2002 | | | |
| | Area (km²) | % | Area (km²) | % | | |
| Forest | 2.94 | 3.0 | 0 | 0.0 | -2.9 | -100.0 |
| Open woodland/trees | 0.057 | 0.1 | 2 | 2.0 | 1.943 | 3408.8 |
| Grassland with scattered trees | 75.14 | 76.1 | 12.8 | 13.0 | -62.1 | -82.7 |
| Wetland | 4.44 | 4.5 | 0.42 | 0.4 | -4.0 | -90.4 |
| Grassland with scattered trees (seasonally flooded) | 6.41 | 6.5 | 2.4 | 2.4 | -4.0 | -61.9 |
| Subsistence farming | 8.36 | 8.5 | 78 | 79.3 | 70.9 | 848.3 |
| Water | 1.33 | 1.3 | 2.77 | 2.8 | 1.5 | 111.7 |
| **Total** | **98.677** | **100** | **98.39** | **100.0** | **1.3** | |

Once more, in the 1950s, transect 6 (Rakai District) was covered by natural vegetation (grassland). However, currently, the transect is under the cover of seasonal crops as indicated on the map.

**FIGURE 59. RAKAI DISTRICT : LAND UTILISATION TYPES ALONG TRANSECT 6**

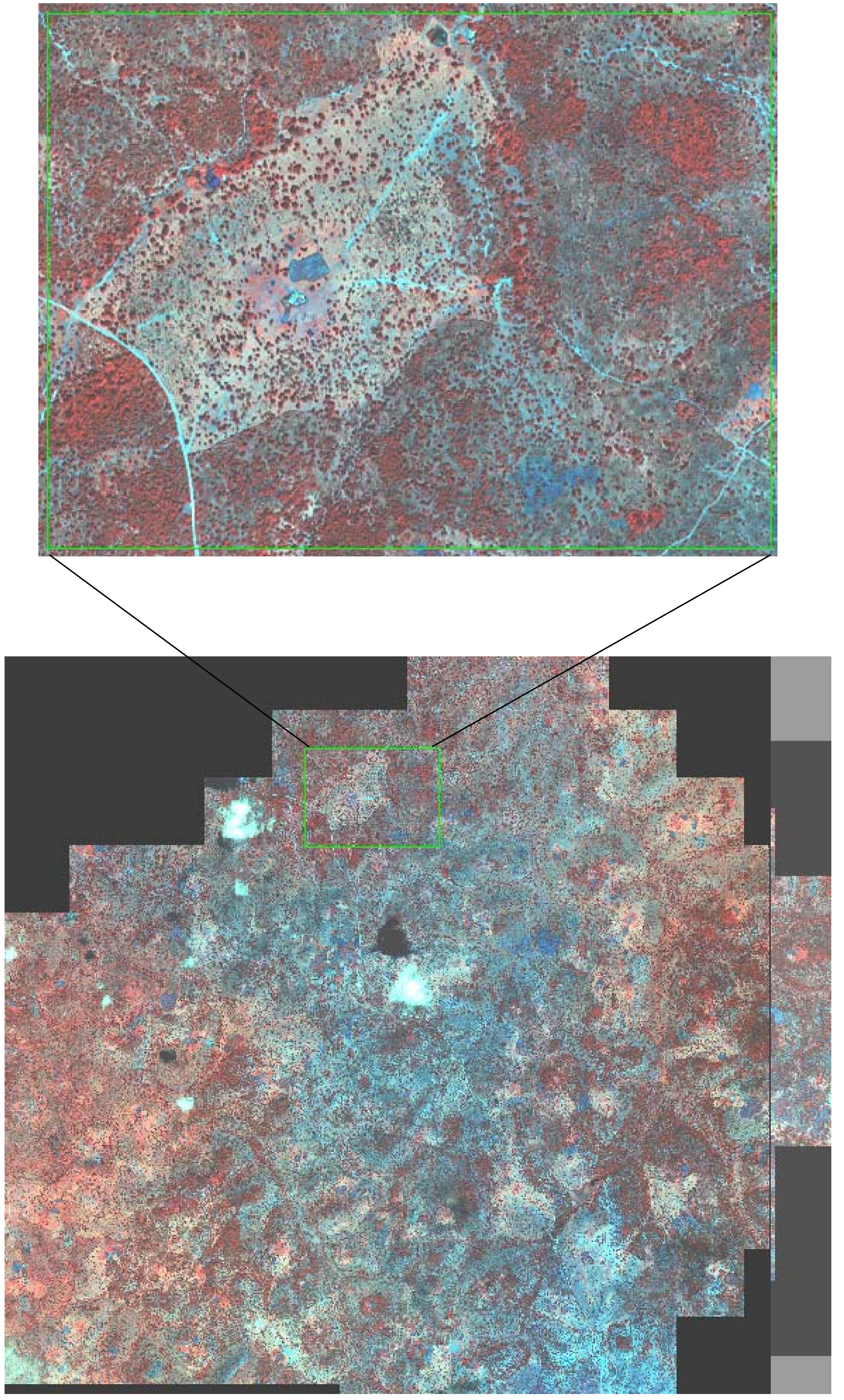



**NOTE:** The dominant weeds a long the entire transect are Black jack, Couch grass, Gallant soldier, Leonotis, *Cyprus spp*., Senecio and Oxalis. -The common grass for grazing a long the entire transect are *Cymbopogon sp., Imperata cylindrical, Cynodon dactylon, Brachiaria sp, Panicum sp., Sporobolus sp., Lantana camaraq.*

## 5.0 GENERAL CONCLUSIONS, RECOMMENDATIONS AND WAY FORWARD

The study has produced a GIS database for the entire Lake Victoria.Kagera Basin for south-western Uganda. The database is on a CD (as shape files). A metadata report has also been produced to help the end-user of the data know the characteristics of the map. Unfortunately, in some case, the metadata may be limited because of lack of proper data descriptions from the source of the data itself. It may be concluded that most of the data, especially on biophysical parameters, is limited by cartographic scales and hence can be used for regional analyses only (scale: 1.250,000).

The database was used to generate information (such as statistics on livestock, land use/cover coverage).In a number of cases, analyses were carried out using the data and the findings have been presented in the previous sections. The information produced will be a valuable resource as a baseline when the actual implementation takes off. However, it is also important to note that in some instances, some data may not be useful as a good baseline resource for the project in future, especially for ecosystem characterisation at the local scale. It is for this reason that we recommend use of IKONOS data ( 4 m) to characterise the sites that will be eventually selected for project implementation in future. Already, MUIENR has acquired an IKONOS image scene (10 x 10 km$^2$) within the Lake Victoria/Kagera Basin (Sanga site, north of Lake Mburo National Park). The IKONOS image is being used to test the potential of IKONOS data to characterise savanna and small-scale farmed ecosystems of the Lake Victoria/Kagera Basin. This test is being carried out against the background presented in the previous sections: that the existing land cover maps are not accurate enough to provide a baseline for local scales. The Sang IKONOS imagery (Figure 60) is also being used to test a methodology of quantifying savanna woodland degradation due to the rampant charcoal industry in some areas of the Lake Victoria/Kagera Basin. Lastly, Sanga site which is being characterised by IKONOS data, may be regarded as an auxiliary site by the FAO-TAMP. This is because Sanga's savanna woodlands are under attack from the charcoal and diary industries, besides expansion of subsistence crop farming. MUIENR Geographic Services will be happy to share its data on Sanga with the proposed project of FAO-TAMP.



**Terms of reference**