Land Use and its Effects on Biodiversity in the Kagera River Basin

History: The Kagera Basin has been inhabited since the Stone Age, some 500,000 years ago, by prehistoric hunters and fisherfolk attracted by the river due to the water availability and game year round. They probably used fire to transform forests to grasslands and for shifting cultivation as well as for protection around homesteads. As the soil fertility lowered they would have moved from the lower basin towards more fertile soils on the ridges of the Karagwe.

Human settlement and land use developed through three successive periods from the Iron Age (1000-500BC) which facilitated the development of sedentary agriculture with long fallows, the 19th C with relatively stable development, due to significant organisation and a flourishing economy, and in the early 20th C a succession of disasters which led to the disintegration of the society. This was followed by recovery during the colonial period, but marked by social differentiation and economic inequity. The initial crops, sorghum and finger millet would have been gradually replaced by more complex intensive cropping systems to meet increasing needs for food and charcoal (for iron smelting). *(section to complete)*

In Tanzania, land use surveys were undertaken in 1995 by the Lake Zone Agricultural Research and Training Institute's Farming Systems Research Programme, and mapped at scale 1:250,000 (Ngimbwa, *et al*, 1996).

Livestock production: The indigenous cattle is the long horned Ankole breed which is robust but has a low productivity. Largely used by semi-nomadic pastoralists for milk it produces 2-3 litres per day and 1-1.5 litres during the dry season. Half the annual average of 325 litres is consumed by the calf. Pressures of extensive transhumant livestock populations on communal grazing lands has major impact on the vegetation composition and is leading to proliferation of less palatable and more woody species (forbs such as *Solanum spp. and Striga asiatica*, perennial species such as *Cymbopogon nardus, Asperagus, Ipomaea, Tribulus, Cleome, Hypoestus* and annual grasses such as *Eragrostis* and *Aristidia spp.).* The trend to more frequent burning for the regeneration of pastures is also favouring certain undesirable species. Grazing pressures are also leading to compaction and complete loss of vegetation on cattle tracks on the hillsides leading to increasing erosion risk.

With the loss of more nutritious perennial grasses (*Botriochloa insculpta, Chloris gayana, Cynodon dactylon, Hyparrhenia filipendula, Panicum maximum* and *Themeda triandra),* the carrying capacity of the pastures is declining in the whole region. In the most suitable areas the pastoralists consider 1.5 head of cattle per hectare as ideal, with supplementary fodder in the dry season. However only a tenth of this carrying capacity can be supported in the drier areas and poorer soils above quartzite rocks which support the less nutritive *Loudetia* grass species and overgrazing is rendering these areas useless.

Within the area of the sedimentary plains in Bukoba district, the majority of the land is under grazing, as poor drainage conditions exclude perennial crops. Sandy, higher parts of delta deposits are locally cultivated. Most of the southern half of Karagwe District is also avoided for agricultural activities, due to marginal climatic conditions, tsetse infestation and lack of infrastructure.

Homegardens and Fallow: There is a clear association between land use type and the underlying soil type, where settlement distribution follows the pattern of availability of suitable land for home garden establishment. Steep land with shallow soils, and poorly drained flat valley floors are avoided for cultivation. Clusters of home gardens generally occupy the well-drained colluvial soils on footslopes under hills and the deeper soils of high level land, as well as deep soils of uplands.

The banana-coffee based farming systems are similar in composition, and differ with respect to relative features such as rainfall, soil fertility, accessibility, population densities and crop acreage and yields. The dominant characteristic is the presence of three typical land use types:

1. Perennial banana-coffee based home gardens (*kibanja*): characterised by its perennial nature and multi-layers, its important number of crops and crop varieties, and by mobilizing and recycling of nutrients from the soil and organic residues. Bananas of various types are the dominant crop, with

dispersed coffee trees. During the two wet seasons the *kibanja* is planted with annual crops such as beans and maize. Households in Bukoba District have one *kibanja* field averaging about 0.6 ha, compared to 1.5-2 ha for households in Karagwe District.

2. Small scale annual crop production (*kikamba*): comprises small fields of annual crops often located near the *kibanja* field. In many cases the *kikamba* field is a deteriorating *kibanja* field. Common *kikamba* crops include maize, beans, cassava, sweet potato, sorghum and millet, occupying separate parts of the field and grown with different practices. Soil fertility is much lower than in the *kibanja* system because few inputs are applied.

3. Extensive annual crop production with fallow (*rweya-omusiri*): on the low quality grasslands (*rweya*), an important land use system is composed of patches of woodlot production and very extensive crop production (*omusiri*). Crop production is limited to cultivation of Bambara groundnuts in rotation with long fallow periods (10 years?), during which cattle are allowed to graze communally and grass cut for mulching the *kibanjas*. Soils on *rweya* land are generally infertile, occurring on land that is too steep, has too shallow or too sandy and droughty soils.

The contrast between the home gardens and associated *kikamba* and the land beyond, dominated by grassland fallow (*rweya*), is more clear in the coastal areas of Bukoba district than in the drier areas in the west. The grass vegetation of *rweya* land is subject to a periodic cycle: after harvesting the annual crop, grazing pressure is high and *Eragrostis tremula* dominates. In subsequent seasons, the taller grasses (*Loudetia phragmitoides, Eragrostis ciliaris, Hyparrhenia spp.*) take over and after about 8-10 years, *Hyparrhenia spp*. dominate, especially in the northern coastal zone. Inland, especially on the Karagwe-Ankolean geological system and sedimentary plains, the composition of the grass layer contains many more species.

The three land use types are inter-related through the transport of organic matter and nutrients. The fertility of the grasslands and annual cropping systems are mined in favour of the intensive *kibanja* system. *Rweya* grasses and *kikamba* crop residues are used as mulch in the *kibanja* fields, where organic materials and nutrients are concentrated in relatively small area. Accordingly, soil fertility in the latter improves at the expense of the other two land use systems. There are few livestock in these systems, although some farmers keep dairy cattle under zero-grazing conditions.

Farmers with access to farm yard manure are able to establish and maintain productive *kibanja's*. However, few sedentary farmers' own cattle and consequently, most *kibanja's* do not accumulate nutrients from manure or fertilisers. Land of good intrinsic soil fertility generally takes up to five years to mobilise nutrients for the *kibanja*, requiring large investment in land and labour inputs. Poor soil fertility acting together with other inter-related factors (such as weevils and nematodes) are largely responsible for the declining banana productivity across the Kagera Region.

In terms of soil and water conservation and sustainability, the banana-coffee based farming system merits much attention and admiration. The establishment of a thick mulch and consequently thick, humic A horizon protects land from soil erosion, provides weed control, hampers a negative nutrient balance, and increases water retention and holding capacity.

Changes in the Ecosystem and Agricultural Biodiversity

A group of farmers in the Kagera river in Bukoba district, near the Tanzania-Uganda border highlighted the following changes:

- longer rains in the past; less reliable starting date of the growing season;
- less water sources; rivers and swamps drying out;
- deforestation and increasing burning of pastures with loss of many tree and pasture species,
- loss of productivity of fruit trees (mangos and oranges) and crop productivity decline.

The district environment and agricultural officers confirmed these reports and emphasised the following issues:

- significant reduction in the size of watercourses and inland water bodies due to water hyacinth infestation;

- soil erosion and vegetation loss, especially in upland catchment areas, due to increasing population pressures and resource exploitation, in particular following civil strife and refugee migrations, including cultivation of former grazing lands, overgrazing and increasing bush burning for tick control, pasture regeneration and hunting. Also noted was the serious reduction and threat of loss of palatable pasture species such as Hyparrhenia rufa ("mburara" after which the district was named) and species suceptible to fire such as Combretum and the increase of invasive species such as "ekasi";

- degradation of river banks by cultivation and the need for awareness raising campaigns to promote implementation of the new National Environmental Law on Wetlands, River Banks and lakeshore Management (Statutory Instruments, supp. No. 1 January 2000, Uganda Gazette No. 5 vol. XCIII);

- degradation of riparian wetlands and loss of their functions of filtering sediments and provision of multiple products such as Papyrus, medicinal plants and fish;

- pollution of water courses through urbanisation near river banks and domestic waste disposal and the need fror biodegradable management;

- stormwater erosion from runoff from road infrastructure and need for watercourse improvement and drainage;

- the need for harmonising environmental legislation among neighbouring countries through participatory approaches and development of local agreements and by laws to facilitate their implementation and through sharing experiences. For example the experience of reducing the size of Lake Mburu National Park in Uganda with Akagera National Park;

- the need for water quality monitoring and control including environmental impact assessment of activities (irrigation, tourism, etc) as well as research to develop baseline data, for example through liaison and coordination with the Nile Basin programme;

- the problem of the excessive cost of electricity and need for urban settlements to resort to charcoal burning even if they have access to the network;

- while there was increasing awareness of wetlands and forest biodiversity, the lack of studies and awareness on agricultural biodiversity loss was noted, including genetic (crop, pasture and tree species change and loss) and ecosystems dimensions (nutrient cyling, carbon sequestration, hydrological regime, pest and disease control).

There have been sensitisation campaigns in Tanzania since two years and in some areas farmers are now aware of the need to plant trees, with a target of 10 trees per household per year. Tree nurseries increasingly include fodder species such as *Casuarina*, *Calliandra*, *Sesbania*, *Glyricidia*, *Leucaena*, The main conflict is cutting trees for charcoal supply to urban areas. There are also campaigns to control water hyacinth for example with the KAEMP and LIVEMP projects through mechanical and biological control.

The main concerns of the farmers regarding plant genetic resources is the loss of their traditional varieties of bananas such as the East African highland banana (*Musa AAA* triploid), and "*kainja*", "*injoge*", "*sweet banana*" and "*ikikonjwa*"- (the latter for frying) species which are greatly appreciated for their taste and texture but are no longer productive due to Panama disease, Sigatoka, weevil and nematode infestation. Efforts are ongoing in the region to introduce disease and nematode resistant varieties, for example by the Belgian KCDP. The FAO-IFAD Farmer Field School (FFS) regional programme is also introducing improved management techniques including clearing of bananas for 2 years to eliminate nematodes and dipping of banana stems in hot water before planting. Traditional varieties that no longer produce are being uprooted by farmers and replaced by *Cavendish* and other exotic varieties. In parallel, urgent efforts are required to identify and develop suitable management methods to conserve and ensure the sustainable use of traditional varieties alongside exotic varieties.

There is also an appreciable loss of local varieties of other food plants, for example cassava varieties (especially noted after the El Nino rains) which are being replaced by varieties resistant to mosaic virus. According to one group of farmers medicinal plants are being maintained in homegardens and they do not cite their loss as a major area of concern in terms of biodiversity loss. However many local tree species are also becoming scarce through excessive exploitation and lack of regeneration resulting from the increasing livestock pressures and burning.

For example, problems are encountered by farmers in the high rainfall north coast areas on Lake Victoria north of Bukoba. This is one of the oldest areas of banana cultivation in Kagera Region and characterised by an accelerated decline in banana productivity. Problems with banana weevil and nematode incidence, widespread Panama disease, and low soil fertility have increasingly forced farmers to substitute bananas with root and tuber crops. This situation could be occurring in other areas and could become more generalised across the region. There has been a gradually increasing westward migration, into drier areas, of land being placed under cultivation, caused partly by the declines in home garden productivity and population pressure. Although Karagwe and Ngara Districts still have uncultivated areas, land with agricultural potential is becoming more scarce.

These changes (shift of cultivation; loss of productivity of banana systems, disease) are already being reflected in the production of more cereals, beans and root and tuber crops, the use of the *rweya* for pineapples and other species that require less management and interest in rice production and other cash crops such as potatoes, soyabean and vanilla.

There are substantial efforts to introduce integrated pest management (IPM) and integrated nutrient management (INM) practices through the FAO-IFAD IPM programme and KAEMP through farmer field school participatory learning and experimentation approaches. Farmers' understanding of ecological interactions is improving, especially in regard to pests and beneficial predators and nutrient cycling. In the 1980s there was much greater use of pesticides, however farmers are more aware of the harmful effects and rather avoid their use, for example, refusing manure from ranches which may contain chemicals from animal dips because of residual effects and no longer use Dieldrin and Cabofurin which led to toppling of bananas. Their understanding of soil biodiversity is very scanty largely because many of the organisms are not visible. This leads to myths regarding pests such as nematodes and perceived damage by visible beneficial organisms such as termites and earthworms. However through farmer field schools composting and other techniques are improving understanding of managing decomposition processes and retaining moisture and a healthy productive soil. Such activities deserve to be widely replicated and expanded through incorporating improved soil biology management, the use of diversified systems with cover crops and agroforestry for protection, nutrient supply and nitrogen fixation as well as conservation tillage practices.

The farmers noted a major concern that issues such as crop and tree species and varietal loss and productivity decline are being raised in farmer meetings but the issues are not being addressed by authorities at higher levels and they receive no feedback. They need a more effective forum to raise their concerns including newsletter, delegates to district meetings and so forth.

Various projects have addressed land management and agriculture and have conducted rapid and participatory rural appraisals and baseline surveys. For example the land use management reports of the Lake Victoria Environmental Management project (LVEMP) including land use, indigenous knowledge on soils and associated management practices to overcome constraints and enhance productivity. In Rakai, farmers reported changing rainfall patterns with late first rains and higher temperatures low yields of short-rain (togo) crops.....

Access to Land Resources and Security of Tenure

Access to suitable land and to means to establish and maintain *kibanja* are dominant factors explaining social differentiation and migration in the Kagera basin. Two types of zones are distinguished:

- Departure zones: where impoverished farmers are excluded from land and migrate, or become wage labourers, as is common in eastern Bukoba.

- Settlement zones: where farmers from departure zones establish new *kibanja's*, such as in western Bukoba District, and most parts of Karagwe and Ngara Districts. Farmers from outside the Kagera Region also settle in these lands, creating new, culturally heterogeneous villages.

Pressures on land are increasing through expanding human and animal populations and declining productivity of fields and pastures. This is leading to increasing fragmentation of holdings in more densely populated areas and migration into drier lands. Pressures and conflicts cited include: exploitation of trees for charcoal, encroachment of cultivation in wetlands and on riverbanks and pressures on national parks and forest reserves, abandonment of transhumant practices of pastoralists and increasing livestock pressures on steeper slopes and more fragile lands especially in the dry season, as well as continual and widespread pressures on soils and continual mining of nutrients.

As seasonal water courses and wetlands are drying out access to water is likely to become a more crucial issue. In the long dry season the pastoralists often encroach on settled neighbouring communities and nature reserves for water and pasture which may lead to conflict. Experience with small dams and water tanks has not proved successful as these silted up due to lack of degradation of the vegetation and maintenance.

The same is true in regard to access to fuelwood and wood for construction purposes, where it is becoming more time consuming and costly to meet household needs. The use of manure for fuel in refugee settlements would otherwsie benefit the cultivated fields.

In Uganda, there are a number of arrangement or rights under which the holder uses the land. The registered freehold or *mailo* (about 60% of holding area) is a tenure whereby the owner holds the parcel in absolute ownership with a legal land title. The unregistered freehold (7% of holding area), whereby the land title has not been transferred into the name of the secondary or current owner. About 60% of the holding area is under the *kibanja* form of tenure, for which the holder operates land on a freehold basis without ownership title and without paying rent. The customary type of ownership (18% of holding area) is one in which individual ownership is not recognised, but rather the right of using the land is allocated by the traditional authorities. Around 5% of the holding area are under leasehold by the Government and some 4% are considered as squatted.

In Uganda, land tenure systems have been complex and dominated by uncertainty for a large number of farmers, constraining their interests in investing on their land, whilst resulting in abuses in land management. The Land Act (1999) lays down procedures for converting customary rights to secure freehold and leasehold rights; i.e. towards private ownership of land. The Land Act, which is expected to stimulate investment on land, awaits implementation. According to the Plan for the Modernization of Agriculture (PMA), implementation of the Land Act will include assistance to land registration to protect the rights of individuals, particularly women and orphaned children; free legal advice and defence in litigation over land ownership; settlement of pastoralists by providing their animals with a permanent source of water, and promoting environmentally responsible development of land.

Fishing and Water Resource Management

Agriculture is supplemented by fishing by communities who have access to lakes and rivers.....

The tributaries to the Kagera River are increasingly drying out during the dry season due to widespread problem of increased runoff and lack of water retention due to the poor vegetation cover. This is exacerbated by loss of wetland areas due to encroachment of agriculture in areas of higher population pressures and increased soil erosion and sediment load in the Kagera river and its tributaries.

The invasion of water hyacinth is blocking waterways and preventing free movement of water which is leading to deoxygenation of water and disruption of the aquatic food chain. This kills fish and other aquatic organisms, affects their breeding grounds and impairs water quality. This also affects human and animal health directly (water volume and quality) and provides breeding grounds for mosquitos and snails, the vectors of malaria and bilharzia. It also disrupts water supply intakes and pump stations for drinking water and irrigation.

Control of water hyacinth is by mechanical and biological means through cutting back and use of two host weevils (*Neochetina eichomiae* and *N. bruchi).* Effective management will require the identification and destruction of source populations upstream as well as management downstream through release of control agents and subsequent monitoring. This requires transboundary collaboration.

Pollution of watercourses is cited as an increasing problem in areas where urban and peri urban settlements are expanding without adequate planning and sanitation measures to keep wastes out of water supplies. The encroachment and drying up of wetlands and swamps is also reducing the natural buffering and filtering capacity.

The promotion of aquaculture could be a really useful entry point to mobilise local interest in the improved management of water resources.

Watershed and Wetlands Management

Land degradation as a result of unsustainable land use practices and increasing human and animal pressures is widespread including deforestation, overgrazing, removal of vegetation for fodder/soil replenishment, bushfires as well as soil mining and inadequate protective cover on cultivated areas. This leads to soil erosion, inadequate water retention to sustain crops and pastures during dry periods, increased runoff and siltation of waterbodies.

A better understanding of land and water linkages and watershed management involving all stakeholders are prerequisites to ensure hydrological regime stability and sustainable water resources. This also requires participatory monitoring to demonstrate the on site and off site effects of better land use practices including: the planting of trees to replace those removed, replenishment of soil nutrients through rotations and more bio-intensive measures (composts, green manures and cover crops for fodder and soil enrichment) as well as integrated pest management, controlled burning and improved pastures and crop varieties and improved crop and livestock systems (varieties, rotations, etc).

As the rainy seasons are being cited as being increasingly unreliable and dry periods more prolonged, water harvesting techniques will become important, both for capturing water on the fields (e.g. small basins around banana plants and infiltration through mulches and cover crops) and for the collection of runoff and flood water in surface and subsurface catchments for later use.

Increasing exploitation of river banks for agriculture was cited as an increasing problem leading to degradation and siltation downstream. In addition to promoting the application of legislation and locally agreed by-laws through participatory processes, well managed and appropriate use of these more fertile soils, with adequate precautionary measures and long term rotations could be explored. Where irrigation is introduced it should be carefully controlled to avoid damage and to reduce inequities in access and rights to water.

As well as being productive environments, wetlands provide important habitats and biological diversity, especially those fringing lakes and rivers. They provide multiple direct benefits including fish, fodder and materials for multiple uses, and also provide refuges and sources of food for fish as well as biological filters for pollution and traps for sediment. The roles of the diverse species in these aquatic systems and the functioning of the systems and their ecological balance is not well known and deserves priority attention to increase awareness and understanding and to catalyse cooperation among local communities and authorities.