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THE VEGETATION OF THE SAADANI NATIONAL PARK AND POSSIBLE CONSERVATION- AND MANAGEMENT STRATEGIES

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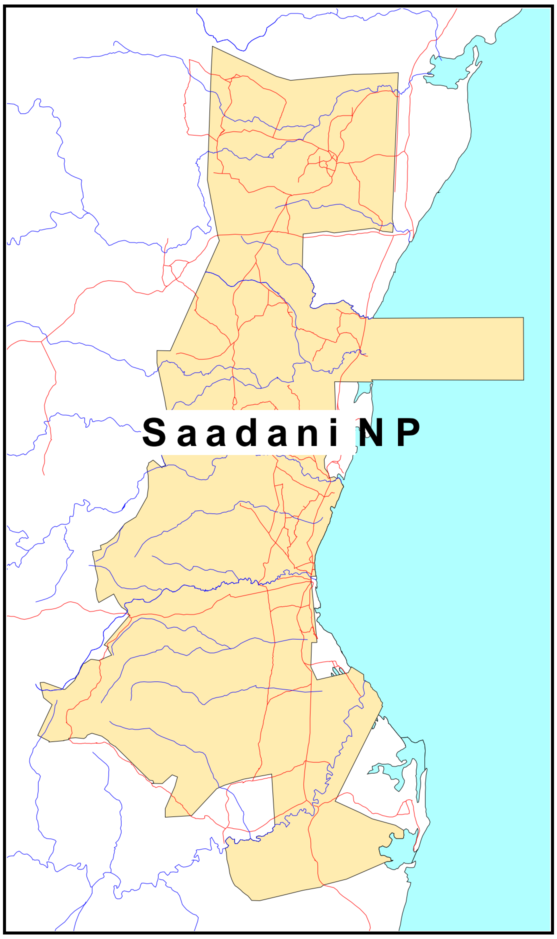
Foreword:

The Saadani Game Reserve together with the Mkwaja Cattle Ranch and some other areas is being transformed into Tanzania's 13th National Park. Germany has been supporting this process under the joint Technical Cooperation Programme.
One of the major objectives of the National Park will be the conservation of the unique coastal vegetation and forests. Very little is known about the Saadani ecosystem and this little paper serves as a first step of presenting some facts on the National Park's vegetation. It also proposes possible conservation strategies to the management.

Rolf D. Baldus, Ludwig Siege



Map of Saadani National Park

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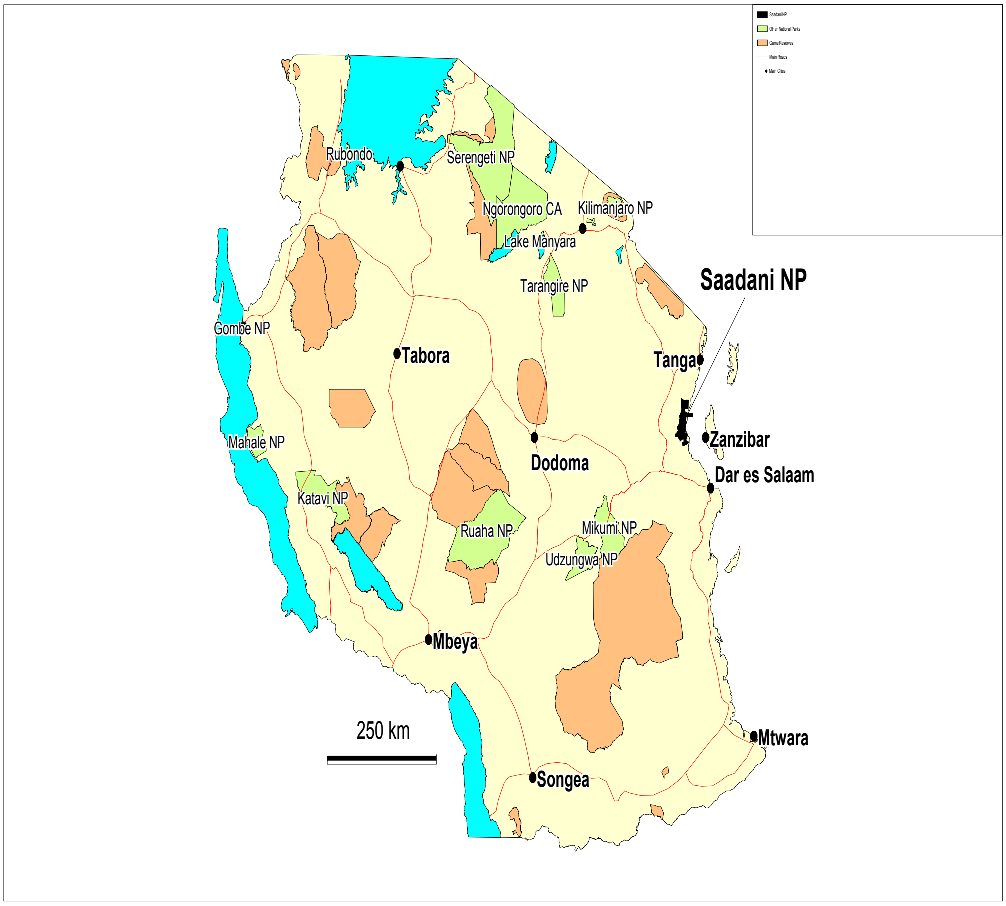
Summary

A brief biogeographical description of the Saadani ecosystem is given. The terrestrial vegetation units are defined and their dominant plant species and soil types listed. The biodiversity and conservation values of the vegetation units are assessed. A transect from the sea westward towards the inland shows the typical topographic position of the vegetation units. The dynamics of the vegetation units is briefly outlined regarding mainly the impact of fire, herbivory and cutting. Based on the vegetational description of the Saadani ecosystem management suggestions are presented stressing in particular the importance of community participation and fire. In view of a sustainable management of the Saadani National Park and its surroundings additional applied research activities are proposed. A summary of the savanna research programme at the former Mkwaja cattle ranch is attached.

Location of Saadani National Park



1. Introduction

Recently the ranch of Mkwaja North has been handed over officially to Tanzania National Parks (TANAPA) for the inclusion in the proposed upgraded Saadani National Park. The gazettement of the 13th National Park in Tanzania should be finalised in the coming months. The reserve thus could become the nucleus of nature and beach tourism along the coast between Bagamoyo and Pangani (GTZ 1999).

The goal of this report is to describe the terrestrial vegetation of the Saadani ecosystem in view of defining the respective conservation objectives and management strategies. In particular the following aspects are stressed:

a) Compilation of major ecological baseline-data from the long term savanna research programme of the Geobotanical Institute (Swiss Federal Institute of Technology, Zurich) at Mkwaja Ranch including ecological data about the coastal forests from the literature;
b) Description of the biodiversity and conservation values of the different terrestrial ecosystems and of their main threats;
c) Definition of the conservation objectives for the National Park and the respective management strategies;
d) Identification of lacks of knowledge and proposition of additional research activities for supporting the future management of the National Park and its surrounding.

In addition, a summary of the research activities at the former cattle ranch of Mkwaja is given in annex A.

2. Study area

Physiographical situation: The proposed National Park is situated in the Pangani District (plus a minor strip in Handeni District), Tanga Region and in the Bagamoyo District, Pwani Region. The protected area encloses the former Saadani Game Reserve (209 km^2, Tobler 2001) the former cattle ranches of Mkwaja (462 km^2, Tobler 2001) and Razaba (about 200 km^2) and Zaraninge Forest Reserve (178 km^2, Peter Sumbi, personal communication). In addition, at Madete Ranger Station (Mkwaja South) a maritime reserve is foreseen.

The future National Park will be part of the Saadani ecosystem, an area of about 2000 km^2 of relatively intact continuous forest-savanna-grassland mosaic (including the coastal forest of Zaraninge) on the northern coast of Tanzania, directly opposite to Zanzibar (Milewski 1993; Baldus et al. 2001). The area is in the centre of the historically rich triangle of Bagamoyo, Pangani and Zanzibar (Baldus et al. 2001) and the vegetation has been widely influenced for millennia by human occupation (Lind & Morrison 1974). Nowadays however, the area is relatively sparsely settled (mainly Swahili people) and one of the least developed in Tanzania.

Geology: The Saadani ecosystem is found on the Mesozoic-Quaternary marine, fluviatile and lacustrine sediments (Griffiths 1993) including much clay but little coral rag. Alluvial floodplains with recent deposits occur along the larger rivers and estuaries and the zone immediately adjacent to the coast is mainly made up of relatively new marine sediment such as coral sand and clay (Milewski 1993).

Topography: The main topography varies from flat (much of the former Saadani Game Reserve and the former Razaba Ranch) to undulating (much of Mkwaja Ranch). Rivers have extensive floodplains. The major part of the former Zaraninge Forest Reserve lies on a dissected plateau between lower Wami and Mligaji Rivers, being itself the source of a short seasonal river, the Mvave River, supplying water to Saadani village (Milewski 1993). The altitude varies between sea-level and 350 m a.s.l.

Soil: Heavy, black clay-rich *mbuga* or black cotton soils in valleys and areas of impeded drainage are widespread. Even on sloping ground texture is rather fine, especially in the subsoil, leading to remarkably poor drainage. The lowest lying basins along the coast are of saline clay. Hilltops and ridges of escarpment are of deep, reddish loamy sand over clay (Milewski 1993).

Climate: As in many regions of East Africa near the equator rainfall is bimodal. There is a short rainy season from October to December during which monthly averages exceed 100 mm. January and February are usually rather dry. Rains start again in March and continue until the beginning of June followed by four dryer months (Tobler 2001). The dry seasons are not very severe since the relative humidity is quite high all over the year and no month is absolutely dry.

There is an increasing rainfall gradient from south to north and from east to west. At the former ranch headquarters in Mkwaja North a mean annual rainfall of 1035 mm has been recorded (25 years; 1955 – 1979, see Bloesch 2002). The variability of annual rainfall is particularly high with a coefficient of variation of 30 %[1]. This high annual rainfall fluctuation reflects the constantly varying impact of two rainfall systems in this area, i.e. the wetter northeast monsoon regime from Tanga and the drier southeast monsoon regime from Dar es Salaam (Walter & Lieth 1960). The rainfall patterns within the Saadani ecosystem are not only remarkably irregular in time but also in space and therefore quite unpredictable.

The mean annual temperature is 26 °C with an annual range of 5 °C and a daily range of 8 °C (Milewski 1993). The climate type in the Köppen system is Aw (Köppen 1931).

3. The main ecosystems of Saadani, their conservation values and threats

The future national park will be the only protected area in Tanzania bordering the sea. It offers the unique combination of terrestrial and maritime ecosystems. It will include four main vegetation complexes:

- A heterogeneous forest-savanna-grassland mosaic;
- The ancient coastal forest on the Zaraninge Plateau;
- A shoreline with salt flats, coastal fringe forests, herbaceous dune vegetation and mangrove forests;
- A maritime ecosystem (this ecosystem will not be further treated in this report).

In the following we give as a brief ecological description of the main natural terrestrial vegetation units (including some typical species), their conservation values and threats.

[1] The coefficient of variation for the annual rainfall is defined as standard deviation expressed as a % of the mean.

Cultivated areas and fallow land will not be described in this report. A typical transect through the main vegetation units is given in Fig. 1.

3.1 Forest-savanna-grassland mosaic

The major part of the Saadani ecosystem consists of a rich forest-savanna-grassland mosaic. Humid savannas with a highly variable woody cover largely dominate this savanna landscape, while small forest formations and grasslands are irregularly interspersed. For the nomenclature we widely follow the classification of Yangambi (Scientific Council for Africa South of the Sahara 1956). We recognise that the word "savanna" has been used in so many different ways and we are aware that some workers, especially in East Africa (Greenway 1943; Pratt et al. 1966; Lind & Morrison; White 1983) have therefore rejected its use. We nevertheless think that the term is a very appropriate one. Savannas do not represent an ecological intermediate case between forests and grasslands but they represent an own biome with typical floristic composition, structure and function (see Klötzli 2000; Bloesch 2002). The strong and complex interactions between the woody and herbaceous plants give this vegetation a character of its own (Scholes & Walker 1993). For our purpose we define the term savanna following Bourlière & Hadley (1970):

"Savanna is a tropical or subtropical formation: 1) where the grass stratum is continuous and important, occasionally interrupted by trees and shrubs; 2) where bush fires occur from time to time; and 3) where the main growth patterns are closely associated with alternating wet and dry seasons."

Water and nutrient supply (depending on climate and soil type) are referred to as primary determinants of savannas, because they define and constrain the potential consequences of herbivory and fire (Scholes & Walker 1993). Geomorphology (relief) influences widely the significance and the interactions of these four main determinants (Bloesch 2002). Furthermore, termitaria may favour the growth of woody plants (see Bloesch 2002).

The savannas are very dynamic (physiognomy) whereby their woody cover (encroachment) mainly depends on fire, herbivory and cutting (see Fig. 2). The balance between grasses and woody plants in many savannas is a labile one, and bush encroachment due to inappropriate management techniques is a widespread phenomenon. Bush encroachment is mostly caused by overgrazing as well as sudden cessation of grazing or reduced browsing pressure, by fire exclusion and frequent low intense early dry season burning (see Bloesch 2002).

W The main vegetation units of the Saadani ecosystem and their dynamics E

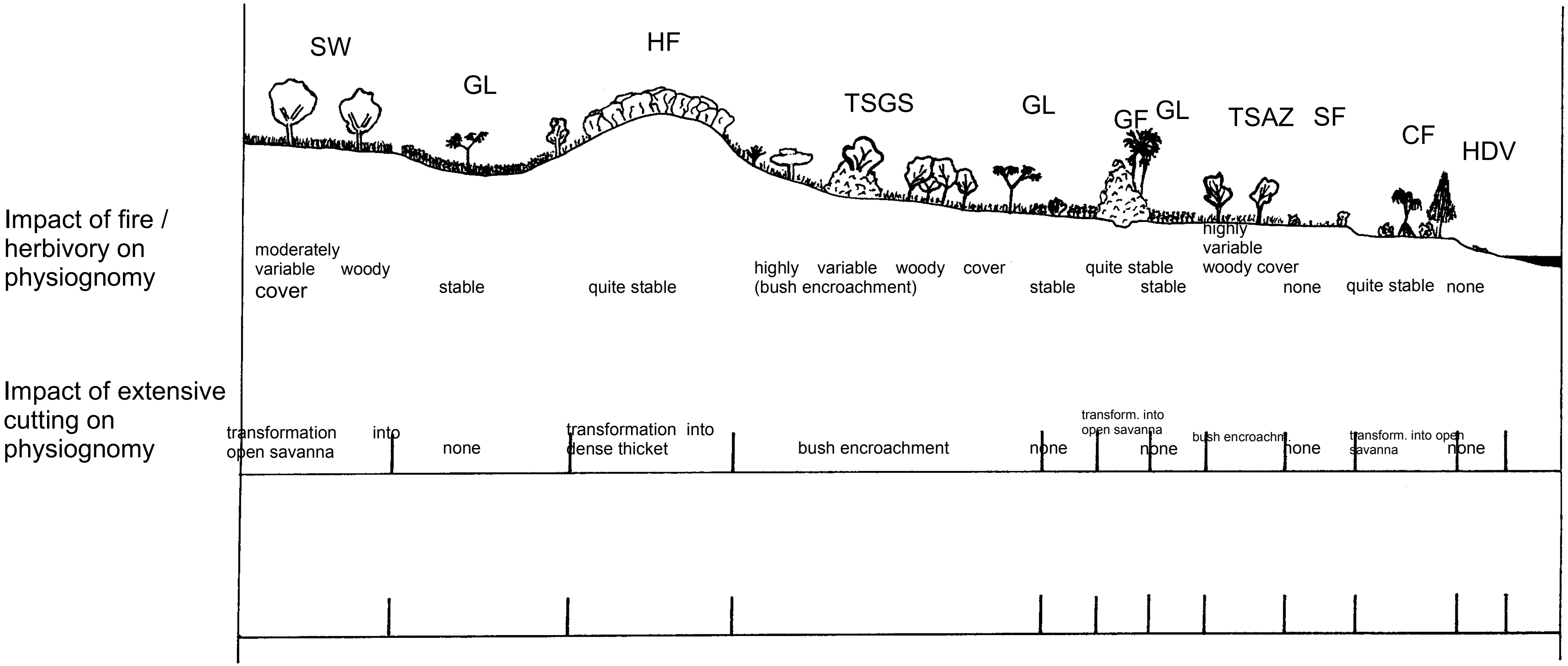


Fig. 1. The woody cover of tree, shrub and grass savannas is highly variable depending on fire, herbivory and cutting. These formations are susceptible to bush encroachment. On the other hand, savanna woodland is more stable; extensive cutting, however, provokes its transformation into shrub/grass savanna. The other vegetation types are quite inert to herbivory (at low browsing intensity) and occasional fires. Extensive cutting, however, will transform gallery forest and coastal fringe forest into open savanna susceptible to erosion. Extensive cutting in hilltop forest will lead to dense-degraded thicket due to many resprouting species. The Zaraninge coastal forest is not shown on the transect.

SW: savanna woodland GL: grassland HF: hilltop forest TSGS: tree to grass savanna with interspersed thicket clumps GF: gallery forest TSAZ: natural tree savanna with *Acacia zanzibarica* SF: salt flat CF: coastal fringe forest HDV: herbaceous dune vegetation

Fig. 2. Schematic diagram of main factors determining tree-grass ratio in a savanna landscape (from Bloesch 2002).

1) In East Africa, however, communities at the low end of the rainfall gradient are dominated by dense scrublands, not by grasslands.
2) Relatively few savanna trees are adapted to seasonal waterlogging (*Acacia zanzibarica*, *Balanites aegyptiaca*, *Hyphaene compressa*).
3) Most savanna trees have a high capacity of spreading clonally (coppice shoots and/or root suckers).

Based on old aerial photographs we suppose that prior to 1952 the vegetation structure at the former Mkwaja Ranch (1952 – 1996/2000) was similar to that of the Saadani Game Reserve with a large part of open savannas. Nowadays Mkwaja has a up to three times higher encroachment ratio than the Saadani Game Reserve, especially in the vicinity of former paddocks where cattle were kept at night (Klötzli 1980a; Tobler 2001). Most of the encroached savannas at Mkwaja are dense stands of *Acacia zanzibarica*. This very competitive species can adapt to a wide range of soil conditions and has a high regeneration potential from remaining rootstocks and / or seedbanks after cutting (Johansson & Kaarakka 1992). But also the doum palm *Hyphaene compressa* and to a lesser degree *Acacia nilotica*, *A. mellifera*, *Dichrostachys cinerea* and *Harrisonia abyssinica* are susceptible to encroachment.

The replacement of a diverse community of native herbivores comprised of grazers and browsers by a single grazing species at Mkwaja changed the type of herbivory; bushes became favoured what triggered the encroachment. Wild herbivores migrate as an adaptation to spatial and temporal variations in the vegetation, while domestic herbivores are more or less restricted in their movements (Tobler 2001). This led to frequent overgrazing around paddocks what did not only directly weaken the grass sward but it also indirectly induced cool burning which favoured the woody components especially by increased sprouting (Bloesch 2002). Furthermore, brush cutting and other measures to control woody plants were not successful and some measures even favoured further encroachment (see annex A).

Klötzli (1980a, 1980b) concluded that any kind of weakening the grass sward (overgrazing, brushcutter, chemical control methods) leads to bush encroachment, especially after drought periods (bushes have access to water in deeper layers). Moreover, the active control of bush fires on the former ranch has certainly contributed to the rapid bush encroachment in many areas (see also 4.2.2).

3.1.1 Savanna formations and grassland

We may distinguish between five naturally grass-dominated vegetation types (see Fig. 1): Woodland savanna, tree savanna, shrub savanna, grass savanna and grassland.

Westward, probably due to increasing rainfall tree density increases eventually leading to savanna woodland having some Miombo characteristics. However, the physiognomy is still savanna-like with a high proportion of Acacias and only a limited number of *Caesalpiniaceae* (e.g., *Brachystegia sp.*). Typical Miombo woodland would be characterised by the overwhelming importance of *Caesalpiniaceae* trees of the genera *Brachystegia*, *Julbernardia* and *Isoberlinia* (Lind & Morrison 1974; White 1983). Miombo woodland occurs in areas with a single dry season (Ernst 1971).

Dominant trees within the savanna woodland are *Acacia polyacantha*, *Acacia robusta*, *Albizia sp.*, *Lannea stuhlmannii* and *Pteleopsis myrtifolia*. The continuous tall grass cover is mostly composed of millet grasses (e.g., *Panicum maximum*). Oxisol is widespread within savanna woodland. On smooth ridges mainly orthic Oxisol occurs while in soft depressions humic Oxisol and on slope acric or rhodic Oxisol prevail. The texture is reddish loamy sand over clay.

A vast area between the shoreline and the savanna woodland more inland is covered with different types of tree, shrub and grass savannas and grassland (less than 2% canopy cover) having a variable woody cover. The savanna formations show different phases of their physiognomy according to the significance of the different disturbances (see Fig. 1 and Klötzli 1980b, 1995; Klötzli & Bloesch 2003). Generally, the woody cover of these savannas increases with slope angle. According to Klötzli (1995) intense cattle grazing favours *Hyperthelia* and *Dichanthium* grasses and *Paniceae* if coupled with regular fires. Grassland occurs in depressions, occasionally with small spring swamps often with *Borassus aethiopum*. Impeded drainage together with very intense fires due to the high biomass of the tall grasses hinder woody growth in this vegetation unit. The interspersed thicket clumps will be described together with the other small forest formations (see 3.1.2). Dominant savanna tree species are *Acacia zanzibarica*, *Hyphaene compressa*, *Terminalia spinosa*, *Sclerocarya caffra*, *Balanites aegyptiacum*, *Acacia mellifera* and *A. sieberana*. Dominant shrubs are *Annona senegalensis*, *Piliostigma thonningii*, *Catunaregam nilotica*, *Acacia nilotica*, *Dichrostachys cinerea*, *Securinega virosa*. Almost monospecific *Acacia zanzibarica* stands occur naturally along or near the coast on saline soils.

In these open vegetation units three major pasture types may be distinguished (for a finer classification and additional vegetational and soil data (water holding capacity and plant-available water) see Klötzli 1980b, 1995):

- *Heteropogon* grass-cover on moderate slope (5-20%), associated with tree and shrub savannas; highly constant species are:
  Hyperthelia dissoluta, *Diheteropogon amplectens*, *Andropogon gayanus*, *Bulbostylis pilosa*, *Cymbopogon excavatus*, *Phyllanthus leucanthus*, *Bubostyls* sp., *Digitaria milanjana* and the ubiquists *Fimbristylis trifolia*, *Cassia mimosoides*, *Panicum infestum*, and *Heteropogon contortus;*
  Mean annual production of the grass layer: 290 g/m^2 whereof 60 % (grasses and some legumes) are palatable for cattle (Kozak 1983); orthic and ferric Acrisol; pH 6.4; the texture is mainly reddish loamy sand.

- *Andropogon-Diheteropogon-Eragrostis* (*Aristida*) grass-cover on gentle slope (0-5%) but not seasonally waterlogged, associated with tree, shrub and grass savannas; highly constant species are:
  Andropogon gayanus, *Diheteropogon amplectens*, *Bulbostylis pilosa*, *Digitaria milanjana*, *Agathisanthemum* boyeri, *Eragrostis superba*, *Bubostyls* sp., *Erythrocephalum zambesiacum*, *Aristida* sp., *Kohautia* sp., *Phyllanthus leucanthus*, *Dalechampsi trifoliata, Cymbopogon excavatus* and the ubiquists *Fimbristylis trifolia*, *Cassia mimosoides*, *Panicum infestum*, and *Heteropogon contortus;*

Mean annual production of the grass layer: 210 g/m^2 whereof 50 % (grasses and some legumes) are palatable for cattle (Kozak 1983); dystric Planosol; pH 6.3; the texture is mainly sandy loam.

- Dichanthium-Sporobolus-Echinochloa (Hyparrhenia rufa) grass-cover on flat area (0-2%), often in slight depressions; associated with grass savanna and grassland; highly constant species are:
  Dichantium bladhii, *D. insculpta*, *Echinochloa halapense*, *Kyllinga crassipes*, *Orthosiphon* sp., *Rhynchosia* sp. *Sporobolus pyramidalis*, *Hyparrhenia rufa* and the ubiquists *Fimbristylis trifolia*, *Cassia mimosoides*, *Panicum infestum*, and *Heteropogon contortus;*
  Mean annual production of the grass layer: 280 g/m^2 whereof 20 % (grasses and some legumes) are palatable for cattle (Kozak 1983); pellic Vertisol; the texture is loamy clay leading to impeded drainage and seasonal waterlogging.

Analysis of long term experimental plots within savannas at Mkwaja have not only confirmed different phases of the physiognomy of the woody cover but also in particular remarkable changes in the floristic composition of the herbaceous (grass) cover. These shifts in the herbaceous layer are partly due to changes in management (more rotation) or then dependent on weather conditions. But many are probably intrinsic species fluctuations of chaotic nature. While trends of shifts of pasture types are quite obvious, trends among the many species are often not clear (see Klötzli 1980b, 1995; Klötzli & Bloesch 2003).

This savanna complex extends inland on a large area and its resilience towards disturbances is quite high (see Fig. 1). The faunal and floral species composition is typical for a savanna landscape. The faunal conservation value is high since the Saadani ecosystem is unique for its most northeasterly population of Liechtenstein's hartebeest, and the rare Roosevelt sable antelope (*Hippotragus niger roosevelti*). Furthermore, it contains the only remaining coastal populations of giraffe, eland, greater kudu, gnu, and perhaps zebra in Tanzania, probably in East Africa, and possibly in all Africa (Milewski 1993).

3.1.2 Small forest formations

We may distinguish the following small dry evergreen or semi-evergreen forests within the savanna landscape:

- Dense low hilltop forests of some hectares on hillocks (humic, acric to rhodic Oxisol following an increasing slope angle);
- Narrow gallery forests along permanent and seasonal watercourses (plintic Gleysol / Fluvisol);
- Riverine forest often nearby water dams (mainly on Mkwaja; Acrisol on the savanna side);
- Thicket clumps within a savanna matrix (similar soil type as surrounding savannas but more developed A-horizon with higher organic matter content).

Thicket clumps of mostly less than 20 m in diameter are irregularly interspersed in the savannas. Thicket clumps and their surrounding savanna formations are very distinct vegetation types with a largely different floristic composition (see also Bloesch 2002). The two plant communities are separated by a sharp ecotone (steep gradient). This is in contrast to the usually large continua between savanna formations. Usually fires only scorch the edge of thicket clumps which is mainly composed of fire resistant species (including lianas like *Cissus* spp.) thereby protecting the pyrophobic species of the inner part (flammability of thicket clumps, see Bloesch 2002). The regular burning increases the sharpness of the ecotone.

Larger thicket clumps often occur on eroded termitaria and are associated with *Manilkara* spp. or occasionally *Tamarindus indica* as nucleus tree. Smaller thicket clumps are often built around *Zanthoxylum chalybeum* on an active termitaria. This tree, together with termitaria, may play a pivotal role in the genesis and development of thicket clumps (see Bloesch 2002). Only few thicket clumps occur in *Acacia zanzibarica* stands. This might be due to the presence of only few large termite mounds of *Macrotermitinae*. The quasi absence of termite mounds in this formation may be caused by the ants living in a symbiotic way in the pseudo-galls of the *Acacia zanzibarica*. Nevertheless, the dynamics of thicket clumps is not yet fully understood.

Thicket clumps usually have a high biodiversity with more than 30 species. Typical woody species in thicket clumps are also *Grewia bicolor*, *G. sulcata, Euclea natalensis, Bridelia cathartica*, *Polysphaeria parvifolia*, *Pavetta* spp., *Ochna* spp., *Combretum constrictum*, *Diospyros* spp., *Canthium* zanzibaricum, *Drypetes* sp., *Scutia myrtina* and *Maerua triphylla* which usually do not grow as individual plant in savannas.

The species composition of the other small forest formations is not known but their floral biodiversity is supposed to be as high as that from thicket clumps. Hilltop forests have many succulent plants in their understorey and a conspicuous cycad (*Encephalartos* sp.). The affinity between the small forest formations with the large coastal forest of Zaraninge is not known.

Due to the high floral and possibly faunal biodiversity of the small forest formations and their important habitat for many animals their conservation value is very high. Small forest formations offer essential cover to bushpig, bushbuck, red duiker and crested frankolin which forage in the savanna and at the forest edge rather than under the dense canopy. Forest edges are also vital for many antelopes and primates (Milewski 1993).

3.2 Zaraninge coastal forest

Coastal forests in eastern Africa occur on a narrow belt along the Indian Ocean from southern Somalia down to Mozambique (including the eastern margins of Malawi and Zimbabwe, see Burgess et al. 2000). Coastal forests include many types of dry evergreen or semi-evergreen closed-canopy forests of different physiognomy (see Burgess et al. 1992; Hawthorne 1993; Clarke 2000; Clarke & Robertson 2000). The total area of eastern African coastal forests is probably the smallest of any major forest type in Africa, and it is also highly fragmented (Burgess et al. 2000).

Burgess et al. (2000) listed 66 coastal forests for Tanzania with a total area of 700 km^2; most of the them having less than 15 km^2. 82% of the total area of coastal forests in Tanzania are found in Forest Reserves (Burgess et al. 2000). The forests mostly are geographically isolated islands found throughout the coastal strip inland to the base of the Eastern Arc Mountains. They are part of the Zanzibar-Inhambane regional mosaic of White (1983). Most of them occur on elevated ground on sedimentary rocks, usually below 600 m a.s.l. (Burgess et al. 1992; Burgess et al. 2000). The best developed coastal forest generally occurs on the eastern side of a hill (see Hawthorne 1993). This is because moisture-laden winds blow off the Indian

Ocean to the east, the eastern side of the hills often receives considerably higher rain and mist than the western side, or flatter ground nearby (Mwasumbi et al. 1994). Sheil (1992) distinguishes between ancient coastal forest on raised ground which pre-dated past sea-level changes and non-ancient coastal forest typically found on the landward side of mangrove forests and in river valleys which were flooded during Pleistocene sea-level changes (see also Clarke & Burgess 2000).

East African coastal forests support many endemic genera and species of plants and animals. For example, there are believed to be six bird species, two mammals, six reptiles, five amphibians and at least 50 invertebrate (in particular millipedes Lovett & Wasser 1993) and 100 vascular plant species endemic to coastal forests in Kenya and Tanzania (Burgess et al. 1993). What makes these coastal forests especially remarkable is not only the possession of many regional forest endemics, but the fact that especially ancient lineage forests often contain significant numbers of locality-specific endemics (Sheil 1992; Burgess et al. 1993; Clark & Robertson 2000). According to Burgess et al. (1993) 100 plant, 37 invertebrate and 13 vertebrate species and subspecies are confined to a coastal forest in Tanzania.

Burgess & Clarke (2000) give a good overview of the extraordinary biodiversity values of vascular plants, mammals, birds, reptiles, amphibians, millipedes, molluscs and butterflies in the coastal forests of East Africa (Burgess & Clarke 2000). Because of the limited area and patchy distribution of the coastal forests, and because of the striking individuality of many of them, all must be given high priority for conservation on an international level (Hawthorne 1993; Clark & Robertson 2000). The lowland Tanzanian coastal forest, which along with the Eastern Arc mountains has been identified as one of the 25 global biodiversity hotspots is in most urgent need of immediate conservation action (Fondo per la Terra).

The high level of endemism, near-endemism and diversity of coastal forests are believed to be due to the existence of forest cover in the area since the late Cretaceous (80 – 100 myr ago), by the isolation of the coastal forests from other African forests blocks since the Oligocene (about 30 myr ago), and possibly by the isolation of the remaining forest fragments by the more recent glacially related climatic fluctuations (see White 1983; Burgess et al. 1992; Sheil 1992). Although climatic vicissitudes throughout the Pleistocene are thought to have caused substantial reduction in the total area of African moist forests, the forest patches of eastern Africa appear to have escaped these changes owing to the remarkable stability of the Indian Ocean currents that bring moisture to the tropical East African coast. This climatic peculiarity has allowed isolated forests to survive in the wettest regions on raised ground whereas they have disappeared from drier areas (see Burgess et al. 1992; Wasser & Lovett 1993).

People have undoubtedly been influencing the coastal ecology for millennia and there can be very few areas of coastal forest that have not been influenced by human activity at some time (Hawthorne 1993). Coastal forest (in particular dry forest type, see Clarke & Robertson 2000) was once extensive in Tanzania but has largely been removed from the coastal area to provide timber, fuelwood and farmland (see Burgess et al. 1992). The Zaraninge or Kiono forest is with about 20 km^2 one of the largest remaining coastal forests in Tanzania (Mwasumbi et al. 1994; Burgess et al. 2000). It is part of the Zaraninge Forest Reserve (gazettement process not completed) which is foreseen to be part of the Saadani National Park. Zaraninge coastal forest is located about 15 km inland from the Indian Ocean and grows principally on a relatively flat dissected plateau of harder limestone and sandstones which may be as old as Jurassic (Burgess et al. 1992). The plateau rises to 300 – 350 m altitude, with steep slopes marking the western and southern margins, and with gentle slopes on the eastern margin. Soils are reddish and sandy, with increased clay content down slopes (Mwasumbi et al. 1994). Zaraninge coastal

forest is surrounded by a savanna landscape and some small forest patches, some of which are 1 km^2 or more in extent (Burgess et al. 1992). The rather open nature of the forest with a proportionally large number of standing and fallen dead mature trees at the eastern side gives a different impression compared to other coastal forests (Clarke & Dickinson 1995). The mortality is not restricted to a particular species and is thought to be caused by a severe drought in 1973-1974 and a cyclone following three years later (Sheil 1992).
Much of the forest remains in good condition, although there has been some logging and farmland encroachment (Mwasumbi et al. 1994). The mean standing volume of the forest is 62m^3/ha with a basal area of 8.3 m^2/ha (WWF 2000). At least 115 tree species were found during the inventory carried out by the WWF (WWF 2000). In undisturbed stands the forest vegetation of Zaraninge is homogeneous over large areas. The canopy of this coastal dry evergreen forest (forest types see Hawthorne 1993, Clark 2000 and Clarke & Robertson 2000) is dominated by *Manilkara sulcata*, *Scorodophloeus fischeri*, *Bombax rhodognaphalon*, *Cynometra* spp., *Erythrina sacleuxi*, *Ficus* spp. and *Ricinodendron heudeolotii*. Rare species are *Uvaria pandensis*, *Uvaria* sp. nov. and *Trychaulax mwasumbii*. Moreover, according to Mwasumbi et al. (1994) there is a probable new species of *Kalanchoe* growing on rocks in the forest, and a possible new species of *Cyperus* growing in the wetland area within the forest.

Notable changes in the vegetation occur on the plateau-sides, at the interface between forest and savanna woodlands, close to an area of wetland within the forest, and in heavily disturbed areas (Mwasumbi et al. 1994). Parts of secondary forests protected from fire show good natural regeneration of forest trees (Sheil 1992; WWF 2000).

The proximity of the forest to the Saadani Game Reserve has allowed game to survive in the forest, whereas it has mostly been mostly eliminated from the surrounding area. At least 40 species of mammals have been recorded in the forest (WWF 2000) whereof African elephant, leopard, black and rufous elephant shrew, and Zanzibar galago are endangered mammals according to the IUCN red list (Clarke & Dickinson 1995). Furthermore, Clarke & Dickinson (1995) listed rare bats, a possible endemic shrew and the lesser pouched rat (*Beamys hindei*). They also reported 17 forest dependant reptiles and 10 amphibians.

Burgess et al. (1991) identified 51 species of forest birds (mostly frutivorous) in Zaraninge, including the vulnerable Sokoke pipit (*Anthus sokokensis*) and three near-threatened species – southern banded snake eagle (*Circaetus fasciculatus*), plain-backed sundbird (*Anthreptes reichenowi*) and Uluguru violet-backed sunbird (*A. neglectus*). Other rare species recorded are tyny greenbul (*Phyllastrephus debilis*), chestnut-fronted helmet shrike (*Prionops scopifrons*), Kretschmer's longbill (*Macrosphenus kretschmeri*), little yellow flycatcher (*Erythrocercus holochlorus*), green tinkerbird (*Pogoniulus simplex*). According to WWF (2000) another 20 species of birds have been recorded in the forest so far.

It is important to note that a small patch of coastal forest occurs on a hilltop (100 m a.s.l.) of the former Mkwaja Ranch about 7 km from the sea (Lowe & Clarke 2000). According to Lowe & Clarke (2000) the coastal forest is typified by short (mean tree height 10.5 m) and widely separated trees mainly legumenouses. The dominant species are *Julbernardia magnistipulata* and to a lesser degree *Hymenocardia ulmoides* and *Baphia kirkii*. Recently, parts of this forest have undergone heavy logging (personal observation).

Gendagenda, another peculiar coastal forest is situated in the vicinity of the Saadani National Park, about 10 km northwest from the northern boundary. The forest ranges from 80 – 545 m a.s.l. with many rocky outcrops on the steeper slopes (Burgess et al. 1992; Burgess & Clarke

2000). Hawthorne (1984) and Burgess et al. (1992) give an ecological description of the forest, the human use and the conservation status.

An increasing number of people lives in the vicinity to the Zaraninge forest. The villages of Gongo and Mbwembwe are situated on the boundary and Matipwili village is only a few kilometres from the park. These local communities represent a potential threat for the sustainable management of this coastal forest.

The forest offers essential products like building poles, charcoal, firewood, game meat, honey, fruits, medicinal plants and vegetable to the local communities on the western and southern side of the forest (see WWF 2000). In addition, it is local tradition to cultivate the margins of the forest (Burgess et al. 1992) and the forest is considered as land reserve for cultivation.

In former times external enterprises were responsible for the majority of the commercial timber extraction (in particular *Brachylaena huillensis*), obtaining licences from the district forestry officer. In 1985 the district authorities suspended the legal exploitation of any forest product in the reserve (WWF 2000). Nowadays illegal cutting of the highly demanded *Mvule* (*Milicia excelsa*) as well as of other species like *Afzelia quanzensis* and *Pterocarpus angolensis* is still a threat (WWF 2000).

In addition degraded parts of the forest (secondary vegetation) have a highly increased fire hazard. In contrast to typical savanna trees, typical forest trees are very vulnerable to fire (see Bloesch 2002). However, fire incidences in the forest are rare (WWF 2000). Only heavily degraded parts of Zaraninge Forest, having enough biomass in the understorey to carry fire, may burn. Primary forests, having a rather scarce understorey, do usually not burn and the fire stops at the edge.

The ancient lineage forest of Zaraninge containing endemic and many rare species has a high conservation value. A strict protection is even more important since coastal forest vegetation is extremely vulnerable to disturbances (Sheil 1992; Clarke & Robertson 2000). Mwasumbi et al. (1994) have shown that heavy human disturbances (especially extensive timber logging, agricultural clearance) of coastal forests reduces their biodiversity values as plant-diversity and the habitats of rare plant species are lost. Furthermore, the vegetation cover of Zaraninge fulfils an important function as water catchment area and erosion control.

3.3 Shoreline

Close to the shore the soils are predominately sandy and coralline supporting low shrubs and some trees. The soils moisture holding capacity is low and some areas are extremely alkaline (Baldus et al. 2001).

In the following we give a general description of the vegetation units of the shoreline since no vegetation survey in detail has been carried out so far (see also Knapp 1973). On the coastal plain occur some salt flats with scattered saltbush form the *Chenopodiaceae* family (e.g., *Suaeda monoica*, *Arthrocuemum indicum*) and some salt-tolerant grasses like *Sporobolus spicatus* and *S. orientalis*. The soil type is gleyic Solonetz or takyric Solonchak.

Coastal fringe forest is found at intervals along the coast. It is composed of *Casuarina equisetifolia* interspersed with *Pandanus kirkii*, an endemic for the Zanzibar-Inhambane region, the invasive cosmopolite *Opuntia vulgaris* and *Scaevola plumieri*, and it separates the beach from the inland vegetation. At other locations (e.g. north of Saadani village) natural *Acacia zanzibarica* stands reach to the beach. The dominating soil type is albic Arenosol.

The beach is covered by a loose and vulnerable herbaceous dune vegetation mainly composed of *Ipomoea pes-caprae* and some Spinifex grasses and *Cyperus* spp. On the beach and along the banks of river yellow-billed stork, grey heron, little egret, water dikkop, and various charadriiforms such as sandpipers are common (Milewski 1993). The particularity of this beach is that it offers a rather uncultivated beach vegetation complex and one of the last significant breeding sites in East Africa for the green turtle (*Chelonia mydas*).

Several places on the coast, particularly at the mouth of Wami river, contain large and still well preserved mangrove swamps (Fondo per la Terra). According to Milewski (1993) the prevailing species of Mangroves are *Avicennia marina* (*Verbenaceae*) and three species of *Rhizophoraceae* (*Rhizophora mucronata* or *mkoko*, *Bruguiera gymnorrhiza* or *msindi* and *Ceriops tasgal* or mkandaa). Mangrove forests provide a resting and feeding place for many bird species, bats, monkeys, hippos and bushpigs (Baldus et al. 2001) and offer a favourable habitat for many maritime species. They are also utilised by humans, primarily for construction poles, dhow masts and firewood, especially to produce lime, salt and dried fish (Baldus et al. 2001).

The shoreline offers a very important habitat for the avifauna. All these small vegetation units along the shoreline are very vulnerable to exploitation and trampling. A future risk is the unplanned expansion of tourism investment along the coast with destructive land-use practices (GTZ 1999).

Concrete threats for all habitats are emanating from poaching by the surrounding communities and urban people and will also depend on the mutual understand between the Park authorities and the local communities (see also 4.2.1).

4. Management of the National Park and its surrounding

In the following we make some suggestions for the management based on vegetational aspects.

4.1 Management objective

The management objective for the Saadani National Park and its surrounding is to conserve the rich vegetation mosaic offering favourable habitat for a unique faunal and floral diversity.

4.2 Management strategies

4.2.1 Community Based Conservation approach

Since the small size of the protected area is not enough to protect the seasonally migratory mammals like sable antelope, kudu, eland, buffalo and elephant (GTZ 1999) it will be essential that these species will be also sustainably managed outside the Park following a Community Based Conservation approach (GTZ 1999; Baldus & Siege 2001). Since the creation of the Saadani Game Reserve conflicts have occurred between man and wildlife due to crop damages mainly caused by bushpigs, baboons and elephants. Furthermore, people living in adjacent areas feel more and more land is being taken away (from community use) to be incorporated into the reserve (Baldus et al. 2001). The active involvement of the villagers in the protection of the wildlife in and outside the reserve requires that they get some benefits for their support.

The governmental protective authorities, the bufferzone communities and other stakeholders should therefore together protect the Saadani ecosystem and utilise it in a sustainable way (GTZ 1999). WWF around Zaraninge forest and GTZ around Saadani Game Reserve have started with a Community Based Conservation approach for the management of the buffer zone and the protection of the reserve. A mutual understanding between park authorities and local communities will be a prerequisite in view of actively involving the local communities in the joint management of the protected area and the touristic development of the area. The management objectives for the National Park and its surrounding should be identified together with the local authorities and villagers. The community participation has to be formalised with official contractual agreement between the governmental authorities and the local communities.

We are fully aware, that only an effective participation of the local communities will allow a sustainable management of the Saadani ecosystems. These aspects, however, will not be further developed here, since it is not the main scope of this report.

4.2.2 Fire policy

The fire management should favour a rich habitat pattern in order to maintain a rich floral and faunal biodiversity within the Saadani ecosystem. According to Rodgers (1979) we should consider two major effects in any fire management. One is of short term, dealing with the structure of the grass cover, its standing crop, availability and palatability. The other is in the long term, dealing with succession and change (woody cover). Savanna vegetation has evolved under recurrent natural and man-made fires. The prolonged effects of fire upon the savanna landscape have resulted in the development of special fire-tolerant communities of plants and animals which are dependent on periodic burning for their existence (see Bloesch 2002).

Burning and grazing/browsing are closely interlinked and have a significant impact on the tree-grass ratio (see Fig. 2) and the species composition in general and thereby also on the fodder value of the habitat. Early season fires provoke grass flush thereby offering additional fodder of high nutrient value during period of nutrient deficiency. Frequent fires favour *Hyperthelia dissoluta*, *Themeda triandra* and *Cyperaceae* in general (Klötzli 1980a, 1995).

Late dry season fires of high intensity help to maintain an open savanna. On the other hand, a no burning protocol as well as an early burning regime of low intensity favour afforestation in general within a savanna landscape (see Bloesch 2002).

Intense late dry season fires may be appropriate to reopen encroached areas. However, since the grass fuel is usually too low in encroached areas to allow high fire temperatures, it may be necessary to cut at least partially the tree/shrub cover one year prior to controlled burning in order to increase the fuel load. The accumulated dead biomass should then produce high fire intensity close to ground at the end of the dry season, thereby possibly destroying the rootstocks of *Acacia zanzibarica*. However, encroached savannas classified as inferior pasture for grazing mammals may offer an excellent habitat for browsers like giraffes or impalas (during the dry season).

A fire management plan should be elaborated defining for all habitats the specific fire regime, i.e., fire prevention or controlled burning. In the case of controlled burning the season and the frequency of burning (intervals of years) must be defined. The challenge of the fire management plan will be to transform the actually uncontrolled fire regime in the Saadani ecosystem into a prescribed fire regime. The fire management plan should be visualised in a map showing the specific fire regimes for the different habitat types.

4.2.3 Suggestions

The management strategy for the Park and its surrounding should consider the following specific objectives:

Protection:

Protect the high conservation value of Zaraninge forest and all small forest formations from illegal timber cutting. Designate adequate bufferzones for covering the needs of local communities (fuel, poles and other forest products). Examine the potential for the sustainable extraction of non-timber products from the reserve.

Encroached parts at the boundary of Zaraninge forest should be protected from destructive late dry season fires by fire breaks or by controlled early dry season burning (at the very beginning of the dry season, as soon as the weather conditions and moisture content of the vegetation allow it in order to minimise damage to the woody regeneration).

Ensure the protection of green turtle breeding sites and ensure the guarding of Roosevelt sable antelope.

Conservation and favouring of rich vegetation mosaic:

Define on a map the fire regime according to the habitat specificity, seasonal fodder availability and fodder quality.

Opening of encroached savannas:

Use intense late dry season fire attempting to reopen encroached areas in favour of grazers and game watching; restore an important elephant populations; study the reintroduction of the extinct black rhinoceros (*Diceros bicornis*) as an important browser.

Water points:

Ensure water availability for wildlife during dry periods (maintenance of the water dams within the former Mkwaja Ranch).

These suggestions should be considered in a management plan. The management plan should include a habitat map based on a detailed vegetation map (see 5). The following habitats may be defined (vegetation types in brackets):

- Forest (coastal forest, hilltop forest, gallery forest, riverine forest around water dams)
- Open savannas with interspersed thicket clumps (savanna woodland, tree, shrub and grass savanna) and grassland
- Encroached savannas (tree, shrub and grass savanna)
- Wetland within Zaraninge and other swamps
- Shore (salt flat, coastal fringe forest, herbaceous dune vegetation, mangrove forest)

5. Proposed applied research activities

According to lacks of knowledge we propose the following applied research activities in view of a sustainable management of the future Saadani National Park and its surroundings:

- Inventory of the flora and fauna of the small Mkwaja coastal forest, the small hilltop forests, gallery and riverine forests and additional inventory of Zaraninge coastal forest in order to assess their biodiversity values (consider the Frontier-Tanzania technical reports 16 and 17, see Clarke & Dickinson 1995 and Clarke & Stubblefield 1995); floral and faunal survey of Razaba Ranch;
- Mapping of the main vegetation units in view of supporting a spatial management plan; the elaboration of a detailed vegetation map is part of the actual research programme at Mkwaja (see annex A);
- Long term monitoring of vegetational shifts in areas of different land-use history, especially in encroached areas in view of better understanding the underlying driving forces (using satellite remote sensing, aerial photographs and ground plots along transect); this analysis should include encroached *Acacia zanzibarica* stands in the Saadani Game Reserve considering herbivory (especially the high population of giraffes and of the introduced gnus) and early burning regime (favouring encroachment);
- Assessment of the vegetation dynamics of Zaraninge coastal forest (succession, regeneration...) and its affinities with the small forest formations;
- Long term observation of the impact of different fire regimes on the main vegetation units;
- Elaboration of a fire management plan;
- Assessment of the migration patterns of large mammals (in particular elephants);
- Development of the tsetse population after abandonment of the Mkwaja cattle ranch (the tsetse was almost eradicated due to successful dipping of cattle in a insecticide containing bath (Fox et al. 1993);
- Assessment of the essential forest product for the local communities (including demand and supply pattern for timber, firewood and charcoal) and identify use options in the Park and the bufferzone which will not endanger the sustainable management of the forest formations.

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ANNEX A:

Brief history of the applied research programme at Mkwaja

A long term applied research programme had been carried out in order to support an optimal pasture management at Mkwaja. Field work had been carried out from 1974 – 1980 and 1992 – 1997. From 1999 onwards the Geobotanical Institute of the Swiss Federal Institute of Technology from Zurich (ETH) continued the research work in the area of the former cattle ranch (Mkwaja South has been incorporated in the Saadani Game Reserve in 1996; cattle ranching at Mkwaja North completely stopped in 2000 and this area will also be part of the future Saadani National Park).

The following main research activities have been carried out:

Bush encroachment: On Mkwaja Ranch, three different types of bush encroachment prevail:

1) Encroachment of *Acacia zanzibarica* (coastal whistling thorn).
2) Encroachment of *Hyphaene compressa* (doum palm).
3) Encroachment of *Dichrostachys cinerea, Harrisonia abyssinica, Acacia sieberana, A. mellifera* and *A. nilotica*.

Four means against bush encroachment can be distinguished and have been tested in trials (Klötzli 1980b):

1) Mechanical means (use of brushcutters; girdling of trees)
2) Chemical means (use of arboricides or waste mineral oil)
3) Biological means (use of browsers such as goats)
4) Fire

Brushcutters have been used in heavily encroached areas in order to reopen the dense stands (see Klötzli 1980a, 1980b). The effect, however, was only temporarily, since resprouting of *Acacia zanzibarica* mainly by coppice shoots was very vigorous leading to even more dense stands than prior to the cutting. Also *Hyphaene compressa* formed dense stands as a response to brush cutting. Furthermore, the brushcutter weakened the grass sward, especially if the treatment was followed by unusual drought.

The use of arboricides and mineral oil against the encroachment of doum palms showed positive results but their application was very labour intensive and costly. Furthermore, the product applied is hardly degradable, remaining in the ecosystem for a long time.

Encroached areas offer good fodder for goats and the first results indicated that goats may be an appropriate mean against encroachment although the trial was too short for getting final conclusion. The trial had to be given up due to many thefts and diseases of this browser. It is also important to note that goats are an important vector for trypanosomes.

The fire trials showed that frequent fires favour *Hyperthelia dissoluta*, *Themeda triandra* and *Cyperaceae* in general (Klötzli 1980a, 1995) and that *Acacia zanzibarica* and *Hyphaene compressa* are highly resistant against fire (Klötzli 1980b).

Currently, the temporal development of the bush encroachment by *Acacia zanzibarica* is assessed considering in particular the role of cattle in the regeneration capacity of this invasive species (Cochard, ongoing PhD thesis).

Rotational grazing: The effects of rotational grazing with cattle, respectively cattle and goats have been assessed in enclosures (Klötzli 1980a, 1980b). Rotational grazing turned out to be promising if the whole lay-out is flexible according to weather conditions what allows to reduce overgrazing and thereby degradation of the rangeland.

Nutritive value of pasture: The nutritive value of fodder from different types of pasture was investigated in digestion trials with goats and sheep (Klötzli 1980a; Kozak 1983). Furthermore, the effects of controlled burning, respectively mulching on the pasture quality was assessed (Klötzli 1980a).

Definition of pasture types and mapping: Five major pasture types have been defined including the determination of fodder values and soil properties (Klötzli 1980b; Kozak 1983). A mapping key has been defined for the elaboration of a vegetation map for the special investigation area of Kalikwenda at Mkwaja North (Klötzli 1995) and for the area along the main roads.

Species oscillation: Species oscillations in the grass and herb layer have been assessed in permanent plots since 1974 (Klötzli 1980b, 1995; Klötzli & Bloesch 2003).

Cattle disease: The impact of weather conditions on the susceptibility to disease of Mkwaja Boran (Zebu race) was assessed over time using detailed ranch reports (Graedel 1998).

Development of large scale vegetation structure: Comparison of the vegetation on Mkwaja with Saadani Game Reserve, using satellite remote sensing, showed that Mkwaja has a up to three times higher encroachment ratio than the Saadani Game Reserve (Tobler 2001). Bush encroachment at Mkwaja also showed a clear pattern in relation to the paddocks where cattle were kept at night. This indicates that the cattle ranching led to a strong increase in tree/shrub cover compared to the game reserve where native herbivores are present. The cloud cover of the used Landsat TM satellite image, allowed to elaborate a rough vegetation map for Mkwaja North and partially for Mkwaja South, while the area of Saadani Game Reserve and the proposed Zaraninge Forest Reserve was mostly too cloudy (Tobler 2001).

Currently, the change of the woody cover (bush encroachment) at Mkwaja and Saadani Game Reserve is further assessed, using aerial photographs from 1954, 1976 and 1981 and satellite images from 1991 and 1998 (Cochard, ongoing PhD thesis). This analysis should also allow to refine the vegetation map established by Tobler.

Impact of vegetation structure on animal population: Currently the impact of vegetation structure on warthogs (Treydte, ongoing PhD thesis) and on grasshoppers (Bohr, ongoing MSc thesis) is assessed.

In addition to the cited publications, the following reports about the research activities at Mkwaja have been elaborated:

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