7. Discussion

7.1 Vegetation structure in relation to hydrology and topography

The vegetation pattern of the study area does not seem to be very different from other wetlands of Southern Africa. Although the definitions of vegetation zones differ, Kafue Flats (CHABWELA and SIWELA, 1986) and Bangweulu Basin (GRIMSDELL and BELL, 1975) show a similar vegetation structure. The study area has the vegetative structure typical of Chief's Island, which covers a fairly large area of the central Delta.

Topographically the area is intersected in 3 terraces, depending on the elevation above sea level. Each terrace contains its own vegetation types as a result of changes in the water balance. The site factor which changes dramatically between the terraces is the availability of floodwater in general as well as the duration, frequency and depth of flooding.
Similarities were described for the Bangweulu Basin by GRIMSDELL and BELL, 1975.

The upper terrace (elevation range > 947.0 m above sea level) is never subject to surface inundation. The following vegetation communities occur in this area:

- Closed riverine woodland
- *Hyphaene petersiana/ Croton megalobotrys* woodland
- *Combretum imberbe/ Croton megalobotrys* woodland
- Dry grassland communities
- *Acacia erioloba* woodland
- *Acacia hebeclada* thicket
- *Pluchea leubnitziae* bushland and
- Rainwater pools.

An area of 6.947 km² is covered by this terrace within the study area.
The woody vegetation along the margins of the secondary floodplain communities is dominated by *Hyphaene petersiana* and *Croton megalobotrys* while *Pluchea leubnitziae*, *Combretum imberbe* and *Acacia spec.* dominate in areas with higher elevation. The woodlands have a structure which ranges from closed canopy to open scattered trees or scrub, and the undergrowth which is prevalent in the open canopy is dominated by the grass species.
Dominant grass species of the dry grasslands are *Sporobolus spicatus*, *Eragrostis spec.* and *Aristida spec.*.

The middle terrace (elevation range between 945.5 m and 946.5 m above sea level) is seasonally flooded and characterised by:

- Primary floodplain communities and
- Secondary floodplain communities.

While the primary floodplain communities are dominated by nearly pure stands of *Cyperus spec.* the secondary floodplain communities are characterised by a mosaic of different grass species, e.g. *Eragrostis spec.*, *Aristida stipioides, Panicum repens, Paspalidium obtusifolium, Setaria sphacelata* and the taller species *Imperata cylindrica* and *Vetiveria nigritiana*. The latter species are found along the margins of the floodplains or termitaria, where elevation above sea level is higher. Primary and secondary floodplain communities occur between the upper flood level and the permanent flooded areas.
The middle terrace covers an area of 4.406 km².

The lower terrace (elevation range below 945.5 m above sea level) is permanently flooded. The following communities occur in this area:

- Madiba communities
- Middle channel communities.

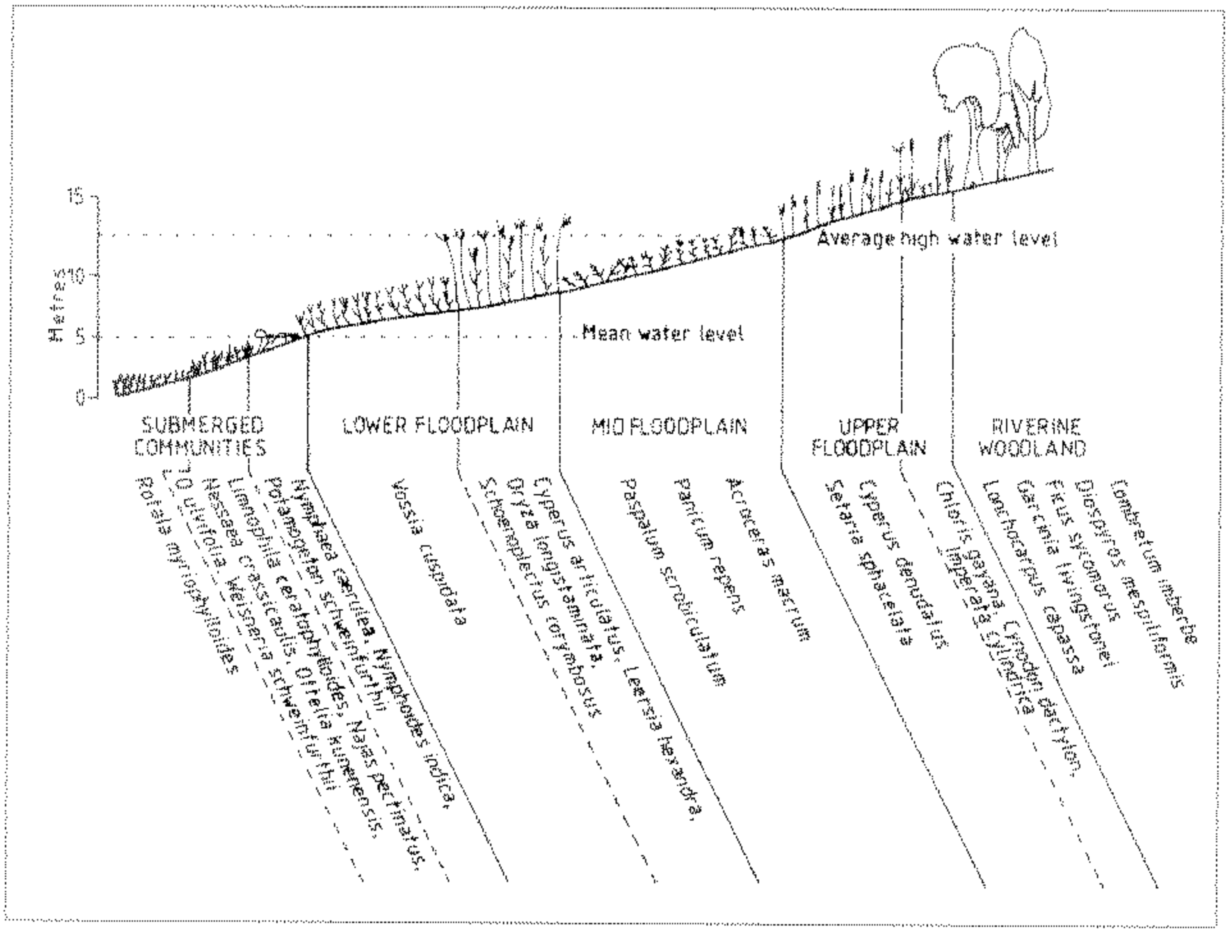
Vegetation communities occurring on this terrace are permanently flooded and characterised by open water bodies and stands of *Phragmitis australis* and *Cyperus papyrus*. *Miscanthus junceus* occurs along the margins. This terrace follows the major water course and is small in extension, within the study area 0.648 km² are covered.

A transitional zone exists between the upper and the middle terrace. In this part the distribution of floodwater changes yearly, depending on the yearly changes in water volume coming through. This transitional zone is restricted to *Sporobolus spicatus* island communities and the periphery of secondary floodplain communities. *Sporobolus spicatus* island communities surrounded by woody vegetation do not get flooded.

Flooding has been the principal determinant of vegetation communities in the Delta. Vegetation pattern generally follows the water contour. Similarities have been observed by CHABWELA and SIWELA, 1986 in the Kafue Flats.

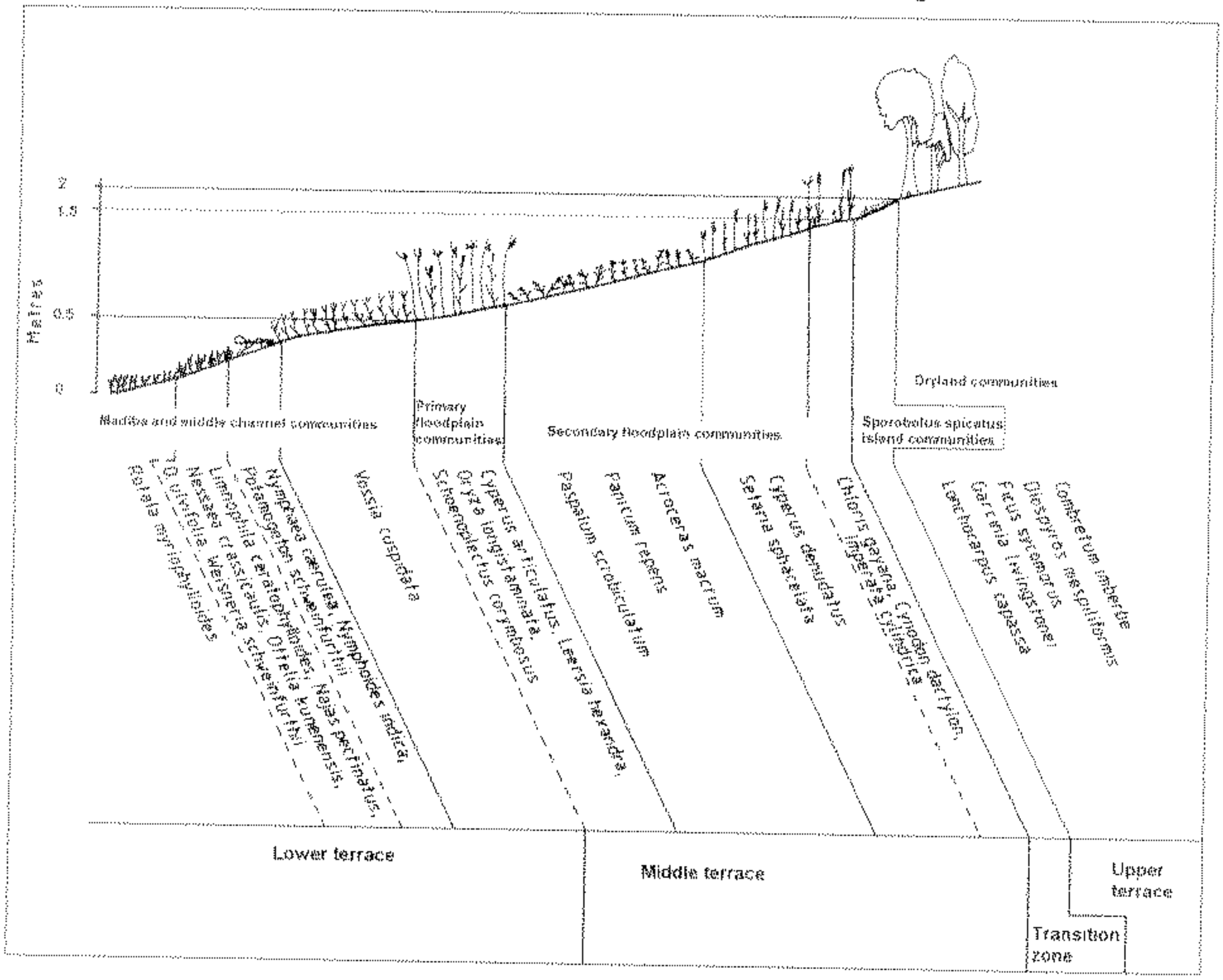
If one considers the dominant plant species of each vegetation community found in the study area the present study shows similarities in the horizontal structure as presented in graphical form by DENNY, 1985 for the Lower Boro River (see fig. below).

figure 9: Vegetation sequence in a section of the lower Boro River (source: DENNY, 1985)



According to the topography this figure has to be modified for the study area as follows.

figure 10: Vegetation sequence modified for the study area based on figure 9



The horizontal zonation of the study area is the same as described by DENNY, 1985. Except the *Sporobolus spicatus* island communities, vegetation is similar. If one considers, that the elevation readings in Denny's graph are the result of a mistake and have to be divided by factor 10, the vertical structure is the same at the lower Boro and the study area. Difference may occur in the expansion of the different zones.

In general can be said that the edaphic aspect determining the plant species composition seems to depend on distance to the water contours and elevation above sea level.

While the ecological site factors are quite similar on the dry upper and the wet lower terrace the site factors on the middle terrace are subject to dramatic seasonal changes. DENNY, 1985 described permanent swamps as detritus-based ecosystems. Accumulated detritus, in form of swamp sludge can be washed out of these areas. The incoming flood transports this detritus into the adjacent floodplain systems where it sinks down. This effect enriches the floodplain with nutrients and valuable food sources for zooplankton (DENNY, 1985).

Productivity on the floodplain explodes within a short time after flooding. Nutrients are released which results in massive plant growth which in fact attracts herbivores. The floodplains then form an important fall back area until the end of the dry season. The organic material, produced during the flooding, is taken out of the floodplain ecosystem by wildlife and so contributes to the surrounding dryland habitats.

After the retreat of the flood the nutrients are accumulated in dead organic matter and will be mobilised during the next flood.

So floodplains form the most important source of available nutrients in the Okavango Delta. Because of this key role in supporting nutrients to wildlife and adjacent habitats, floodplains should be taken as the most important link between the water courses and the adjacent dryland habitats. Because of the extreme seasonal changes in them, floodplains support a high diversity.

7.2 Long term changes on vegetation structure

Most publications on changes of the vegetation structure in the Okavango Delta consider the changes of major water courses as a result of seismic activities (STANDISH-WHITE, 1972), massive growth of aquatic plant species (THOMPSON, 1975) or sedimentation of bed-loads (MCCARTHY & ELLERY, 1997).

Floodplain topography shows that changes of the flooding pattern are also likely to take place in the floodplains themselves. The typical morphology of a floodplain is that of a plate-like valley. Such plate-like structures were observed on Lower, Upper and Eastern floodplains during the present study. Aerial photographs show that two different types of floodplains have to be intersected:

a) Floodplains directly connected with a permanent water course – Upper and Southern part of the Lower floodplain
b) Floodplains connected with other floodplains – northern part of the lower floodplain and adjacent eastern areas.

Generally can be said that floodplain topography is similar. Only along the margins floodplains show small elevation differences.

During the flooding process the type A floodplain fills up. If a certain level is reached, this floodplain spills over and floods the type B. So small elevation differences in the morphology of the floodplain rim determine the flooding of type B floodplains.

Depth, duration and frequency of flooding in secondary floodplains depend on microtopographical features of the floodplain itself and the amount of water coming in during the flood event. Especially on the secondary floodplains the ecological factors mentioned are nearly similar. Because of this similarity and the relatively low flood depth microtopographical changes can cause big changes in water distribution.

Such changes can be caused by erosion or the establishment of termitaria, especially adjacent floodplains can be completely cut off. The occurrence of *Pluchea leubnitziae*, as a pioneer plant which does not tolerate surface inundation, indicates a formerly flooded area which is now cut off from flooding. Large stands of *Pluchea leubnitziae* can be found in the western parts of the study area. Topographical changes are likely to take place especially along the margins of secondary floodplains. This process may speed up during periods of droughts and/ or blockages of the floodplain inlet and water courses in the upstream areas.

Large animals like elephants and hippopotami are able to influence the morphology of a floodplain on a fairly large scale, by using the same paths for ages. These paths can be up to 0.5 m deep compared to the surroundings and play an important role in determining the flooding pattern of a floodplain or floodplain system.

One would suggest, that the main reason for changes in the vegetation structure are changes in the flooding pattern caused by the factors mentioned above.

Another effect of determining the plant species composition of an area, especially in woodlands and floodplains, is the utilisation by herbivores.
During times of droughts animals are able to change the plant species composition dramatically, resulting in the dominance of non or less utilised plant species. Because of a selective utilisation plant composition can change into a more browsing or grazing resistant one.

Such processes may speed up during periods of drought when the herbivore density concentrates in certain areas or if population of herbivores exceeds the carrying capacity of the ecosystem.
Fire is another secondary factor which can determine the species composition of an area.

A better germination of seeds of various plant species occurring in tropics (up to a certain level) because of higher temperatures in soil is described by KNAPP (1966, 1967).
Within the Okavango Delta *Hyphaene petersiana* seems to be highly adapted to fires. The burning away of the exocarp and the simultaneous heat treatment seem to speed up germination. Fire has virtually no negative influence on mature palm trees as they do not have any bark which can be damaged. The fact that they are more resistant to fire than other species possibly explains the numerous pure stands of *Hyphaene petersiana* along the fringes of large islands in the Delta.

DENNY, 1985 described the grass *Imperata cylindrica* as a fire climax species.
After the burning of the Lower floodplain during the present study a massive growth of this species could be observed in this area.
Differences also have to be made between surface fires and peat fires. Peat fires occur in areas which were formerly permanently flooded, and have dried out. These fires can burn for a long time in the sub-surface peat, with heat from burning drying the surrounding peat. This results in collapse and compaction of the peat, thus lowering the surface. High temperatures and chemical changes result in a permanent change in the area's ecology.
Observation on the effect of a peat fire in the Gedao lediba of the Santanadibe system which has dried out in recent drought indicates that all peat and traces of swamp vegetation (e.g. *Phragmites* roots) have been burnt and underlying soils have been baked dry resulting in soil profiles similar to parts of the lake bed at Lake Ngami. It is obvious that peat fires result in permanent changes and are a key factor affecting local plant dynamics through changes to soils, topography and drainage as observed above and by MCCARTHY et al, 1986. DENNY, 1985 described an impact of fire on the topography in the abandoned section of the Nqoga channel.

Fires occur in the Okavango Delta for various reasons but there has been no attempt to relate fires as the principal determinant of vegetation types in the Delta; one would only suggest the effect of fire to be secondary as compared to other factors. However, since the aspect of fire was not specifically investigated in the study, its effect should be viewed with caution.

Nevertheless, more permanent burning will cause a loss in diversity of plant species composition and fauna as a result of abiotical factors of the soils.

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Software

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- ArcView GIS Version 3.0a; ESRI - Environmental System Research Institute, Inc.
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