PROCESSING OF SPATIAL DATA TO MAP DAMBOS IN THE ZAMBIAN COPPERBELT.

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Introduction: "Dambo" is a southern African term applied to a variety of wetlands which occur throughout central southern Africa. Dambos are geomorphological features which are covered by grass and are seasonally inundated. These wetlands are recognised as being of considerable hydrological and agricultural importance [1].

The area of interest (AOI) discussed in this paper is an intensively utilised area that lies within Zambia's Copperbelt Provice. It covers 445,000 ha of the upper catchment of the Kafue River on the border between Zambia and the Democratic Republic of Congo.

Dambos in the Copperbelt are grassy, treeless, concave depressions at the source of most streams. These are known as headwater dambos. They are important natural resources as they perform several functions:

- they are perennial water resources in the dry season and support intensive cultivation year-round, and
- they receive a variety of industrial effluents from mining activities and play a role in the amelioration of these effluents [5].

The importance of dambos arises from their extensive distribution in the headwaters of many streams where their wetland properties, such as soil-water regimes, vegetation and channel characteristics [1], impact positively on downstream water quality. Dambos are observable in virgin areas of the AOI as exaggerated drainage patterns. Dambo conservation is a priority as these landscape elements are important natural ecosystems and support significant agricultural production in the AOI.

Agricultural settlements are frequently located near dambo fringes, which are used as water sources [4]. They are used for cultivation: ridge fields are used for growing sweet potatoes and cassava is grown on specially constructed mounds which promote drainage and prevent water logging of soils during the rainy season. Other crops grown include maize, groundnuts, millet and vegetables.

Dambos many kilometres away from a settlement may be converted into intensively farmed fields, which often cover most of the dambo surface. Ridge cultivation and trenches result in linear erosion, leading to the development of gulleys. Removal of Mushito vegetation accelerates headward erosion and incision of the stream channel. Dambos thus have special significance in the AOI: they are important resources for the survival of small-scale farmers and they are sensitive landscapes that provide important hydrological services.

Consequently, dambos are a key resource and play a role in determining the future patterns of human land use. They are also important resources in water pollution amelioration. A dambo land cover map is necessary to assess current land uses and to plan for future changes in land use.

GIS-linked image processing for dambo mapping. Dambos are difficult to map in the AOI. They have less vegetation cover than the miombo woodlands, but more than agricultural areas. Consequently, in normalised difference vegetation index (NDVI) images, they are lighter than cultivated fields, but darker than woodland. In thermal images, they are warmer than the woodlands in some areas, but not in others, and are generally cooler than agricultural areas.

Area covered by dambos: To overcome the intermediate nature of dambo signals, several source maps were prepared using data that clearly showed dambos: an NDVI image, a thermal image (Landsat Thematic Mapper (TM) band 6) and an infra-red image (band 5). The thermal image was resampled to 25 m (to correspond with the other images) and subjected to a high-pass filter to reduce blockiness.

All three images were sampled at known dambo locations, and an attempt was made to gather a wide variety of dambo conditions. The resulting sample populations were used to classify the images. The first standard deviation (SD) around the mean was assigned the value of one. The second SD was assigned a value of 0.5 and the third 0.1. The input images were then classified according to the probability of a random pixel representing a dambo. This was achieved by comparing the pixel value to the distribution obtained for typical dambo pixels. The resulting probability maps contained values ranging from zero (no dambo) to one (dambo present).

Non-spectral data was used to produce other input maps. A topocadastral map was digitised to extract contours and streamlines. The former were used to produce a digital elevation model (DEM) using interpolation algorithms in both ILWIS 2.2 and PCI MODELER.

Only very flat areas were assigned the value of one. Moderately steep areas were assigned a value of 0.5, steep areas assigned a value of 0.1 and very steep areas were set to zero. A distance map was generated using the streamlines so that only areas near watercourses could be accepted for classification as dambos. This requirement is acceptable in the AOI, as pan dambos are absent.

These maps were combined in ILWIS using a fuzzy logic algebraic product. The final map was classified as “dambo” or “not dambo” and then majority-filtered to reduce noise. This procedure was undertaken using Landsat data for 1984, 1998 and 2000. The processing flow diagram is shown in Figure 1. below.

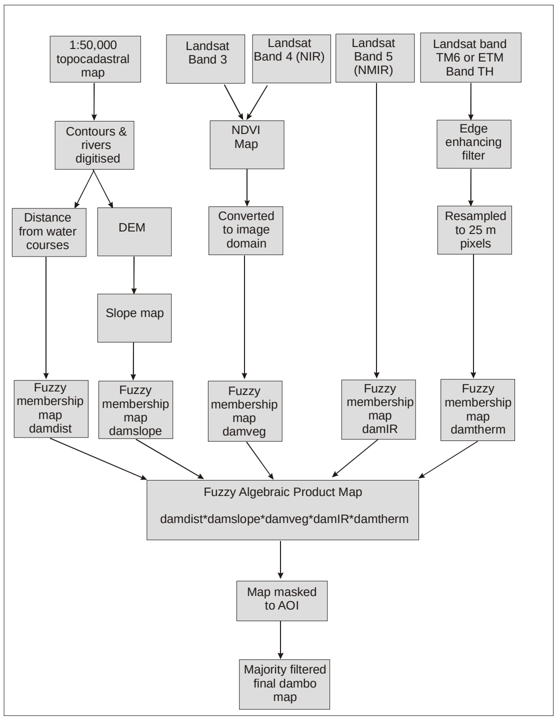

Fig. 1 Image processing flow diagram for the production of classified dambo maps in the AOI (ETM band TH is the normal gain thermal channel).

Dambo processing results: Garlick [2] reported in 1961 that dambos covered more than 10% of the Copperbelt. Applied to the AOI, this equates to approximately 44,500 ha of land. In 1984 the image processing procedures outlined above yielded a dambo surface area of 30,650 ha within the AOI. In the 1998 data set, the area covered by dambos was calculated to be 30,760 ha. With the 2000 data set, dambos were found to cover only 15,194 ha, but this result was discarded due to significant differences in spatial and spectral resolution between the TM and Enhanced Thematic Mapper (ETM) thermal channels. These differences may have rendered the image processing results incomparable.

Over the 14-year period between 1984 and 1998, dambos increased in area by 0.5 percent. Given the large number of variables in the calculation of these areas, this change may be assumed to represent stability in dambo area and therefore no significant change occurred. The substantial difference between Garlick’s figure and the calculated figures may imply long-term dambo destruction. It may also reflect the extremely rough nature of that author’s estimate and the fact that the estimate was made for the entire Copperbelt but is only applied to the AOI here. A map showing dambo distribution in 1998 has been produced.

References:

[1] Bullock, A. (1992), The role of dambos in determining river flow regimes in Zimbabwe, Journal of Hydrology, Vol.134, Elsevier Science Publishers B.V., Amsterdam, the Netherlands, 349-372. [2] Garlick, W.G. (1961), Geomorphology, The Geology of the Northern Rhodesian Copperbelt, ed. F. Mendelsohn, MacDonald, London, U.K., pp 11-16. [3] Mäckel, R. (1974), Dambos a study in morphodynamic activity on the plateau regionsof Zambia, Catena, Vol.1, pp 327-365. [5] Von der Heyden, C.J., D. Limpitlaw & M.G. New (2003) Natural wetlands for mine effluent remediation? The case of the Copperbelt, *Monitoring of Tropical and Subtropical Wetlands*, Maun, Botswana, 04 December - 08 December, Harry Oppenheimer Okavango Research Centre and University of Florida.

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