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The size of the Lake Chilwa wetland

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Introduction

Lake Chilwa is a very flat and shallow internal basin surrounded by swamps and marshes in most areas, and with no outflow. It is situated in southern Malawi on the country's eastern border with Mozambique. The lake's altitude is 622m above sea level (asl). The deepest part of the lake is less than 5m (in the central-southeastern part); in most areas it is just 2-3m deep. Because of its shallowness, its open water surface area may contract and expand severalfold in years of extreme high or low rainfall. This, plus the absence of any outflow, has in turn led to high salinity of the lake water. The size of the catchment area of the Lake Chilwa basin is 8,350km^2, of which 2,700km^2 is situated in Mozambique. The wetland itself is often described as being about 1,850km^2: one-third open water, one-third marshes and swamps, and one-third floodplain grasslands (this is the figure that is usually quoted by other authors; it originates from Lancaster, 1979a). The Lake was larger in both the historical (evidence from the nineteenth century) and geological pasts: there at least four ancient terrace levels visible, indicating five drops in lake level.

Lake Chilwa has been the focus of extensive biological research in the late 1960s and early 1970s, carried out by members of the Biology Department of Chancellor College, University of Malawi. Important results of these investigations have been published in the *Lake Chilwa Monograph* (Kalk et al., 1979), a compilation of articles by different researchers.

Recently, the Biology Department has again embarked on studies at Lake Chilwa, starting off with efforts to establish the present biological status of the wetland. This work was done at the request of the Government of Malawi, which needed the data to gain accession to the Ramsar Convention, the international convention for conservation and sustainable use of wetlands. In the near future, the Biology Department will be involved in the new six-year DANIDA-funded Lake Chilwa Wetland and Catchment Conservation Programme.

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It is an opportune moment, therefore, to establish some basic geographical data for the Lake Chilwa wetland in the last decade of this century. Certain estimates of area size from Kalk et al. (1979) have often been quoted in documents of later date, while at the same time some of the writers of chapters in this monograph seemed to disagree about the actual size of the wetland and its component areas (open water, marsh, arable land, etc.). This article then is also an effort to re-assess the validity of these data. Using recent reports, maps, satellite images and field observations, information has been collected concerning the present size of the lake and its surrounding vegetation cover; and these data have been compared with the information provided in Kalk et al. and other early publications.

Methods

Sources

Documents from the Land Resources Evaluation Project, Malawi: *Land Resources Appraisal of Liwonde ADD* by Venema (1991); and *Land Resources Appraisal of Blantyre ADD* by Paris (1991). Both reports contain maps of which in each case was used: Map No. 4, Present Land Use and Vegetation, scale 1:250,000. The reports and maps were published in 1991, but the maps were based on aerial photographs taken in July 1989.

Satellite images and maps based on them: LANDSAT, 1:250,000, No. 8 Mangochi and No. 9 Blantyre; produced for the Forestry Department, Malawi Government, by Satellite Bild, Sweden; images taken on 9 September 1991.

The 1:250,000 topographic maps produced by the Department of Surveys, Government of Malawi, 1988.

The National Water Resources Master Plan: Annex 3 — Hydrological Data Part 1, WRA 1 to 3 (March 1986).

ADD maps

The above mentioned maps were used to work out most of the area calculations. Cartographic measurements were done at the Land Husbandry Training Centre, Zomba, with a digital planimeter (Sokkhisa PLACOM, KP-90N). Human error in measuring is a factor that could not be excluded; however, repeated measurements revealed that deviations never exceeded 5%.

See this article's Annex for a copy of the maps that were used. The maps show a mosaic of units representing different land uses. It concerns 'pure' mapping units (labeled with one code): 75% or more of one land use or vegetation type; and 'complex' mapping units (labelled with a double code), which are made up by one dominant land use covering 50-75% of the area and another type covering 25-50%. Based upon these percentage ranges, I have, in the case of these complex units, for ease of calculation assumed two-thirds coverage for the first land use type and one-third coverage for the second type.

The following criticisms can be levelled against the correctness of the maps. Firstly, certain mapping units will be underestimated (like B1, C1 or E; see Annex) as they are either too small to be shown on this map as pure units, or occur in association with another unit, but with coverage of less than 25%.

Secondly, the producers of the maps were more concerned with agricultural uses than natural vegetation types, and do not distinguish between the biological categories of floodplains, marshes and swamps. They indicate the major marsh areas with the connotations MW and WM, suggesting that these marsh areas contain numerous pockets of open water. However, it will depend on the lake water levels and the seasons, how much open water within the marsh and swamp areas will be discernable on the aerial photographs used for the production of these maps. Also, the makers of the maps have not clearly delineated borders between the WM and MW areas. Still, I have used the two-thirds/one-third split to the best of my ability.

Lastly, some mistakes have been made by the makers of the maps when printing the codes in the units. When I felt confident enough (for instance, after personal inspection of the area), I have corrected such mistakes.

Results and discussion

Area sizes

The results from the planimetric measurements on the ADD maps concerning area sizes are shown in Table 1, together with the values produced in the *Lake Chilwa Monograph* (Lancaster, 1979a). The total area of the wetland amounts to 2,325km^2; this compares with 1,850km^2 found in the 1970s.

The present total was obtained by adding all smaller mapping units together. When the planimeter was used to trace the outline of the whole wetland (which brought with it

Table 1. Size of areas with different vegetation cover or land use in 1990 and in the 1970s. Comparison based on the information gathered from the ADD Land Use maps, 1990, and the figures given in the Lake Chilwa Monograph for the 1970s; in km².

Land use or vegetation	1990	1970s
Open water	1,054	678
Marsh	803	578
Grasslands: floodplains and dambos[1]	220	580
Subtotal	2,077	1,836
Wetland rice cultivation	114	
Irrigated rice cultivation	29	
Dimba cultivation	90	
Islands	15	14
Total	2,325	1,850

1. The total for seasonally wet grasslands is composed of 132km² for floodplain grasslands and 88km² for dambo grasslands. Dambo grassland units are not shown on the Liwonde ADD map at all, but only on the Blantyre ADD map, which covers the southern shore of the lake. Surprisingly, on the latter map there is no mention at all of floodplain grasslands, while visits to the area confirmed their presence. The producers of the maps have most probably made some mistakes here.

some difficulty in manoeuvring the instrument), a total of close to 2,400km² was obtained; this is a value close enough to maintain confidence in the separate area calculations.

The total area measured on 1:250,000 topographic maps, namely sheet 8 (Mangochi) and sheet 9 (Blantyre), published by the Department of Surveys, Blantyre (1988), resulted in a total wetland size of 2,200km²; on these maps the boundaries of the wetland are rather ill-defined and therefore partly conjectured.

A look at any standard map of Malawi will confirm that the Lake Chilwa wetland roughly covers an area of 40km (west-east) by 60km (north-south), giving a total of 2,400km². The value of 2,325km² calculated in this study is clearly in line with this. Of the 2,325km², 173km² (7.5%) is Mozambican territory, mostly marsh with some open water and floodplains. Not included in this area total for the Lake Chilwa wetland are the following two smaller wetlands, as they are not contiguous with the main wetland: Bugue Marsh, south-east of Lake Chilwa, about 50km², completely situated in Mozambique; and the middle Sombani river basin, south of Lake Chilwa, mainly marsh but also including the open water of Mpoto Lagoon, more than 60km² of which the larger part is located in Mozambique.

It is particularly important to note that the present study found a much higher value for the total area of the wetland than the value obtained and used by the biology research group in the 1970s.

Component parts of the wetland

Differences in values found for the component parts of the wetland don't present much of a problem. Because of its unique features, especially its shallowness and the absence of any outlet, Lake Chilwa shows large variations in water levels, seasonally as well as annually (Lancaster, 1979a, p32). Comparatively small changes in amounts of rainfall in the catchment area can lead to significant changes in lake level, which in turn affect the size of the open water area. Water level changes at Chilwa during a 'normal' year are relatively small (about 1m) on a vertical scale, but this affects a large area of about 500km^2 in the horizontal dimension (Howard-Williams, 1979, p121).

Thus, the areas of open water, swamp, marshes and floodplains vary with the level of the lake in any year. For instance, the area of open water measured 594km^2 in 1969, and 678km^2 in 1972, as a result of a rise in lake level of only 0.4m. 1972 was supposedly a year of average lake levels, but elsewhere it is mentioned that at the mean lake level of 622m asl the area of open water is approximately 600km^2. In the extremely wet season of 1978, the lake level rose to about two metres higher than average and the water flooded large areas of the floodplains. However, these are all changes of the components of the wetland relative to each other: the total area can be expected to remain the same. (All data from Lancaster, 1979a, p19, pp 26-7).

Apart from these annual (seasonal) changes of about 1m, the lake level also fluctuates at more or less regular intervals over a number of years by 2-3m (Lancaster, 1979b, p43). With lowering lake levels, up to one-fifth of the lake bed might be exposed at intervals of six years (McLachlan, 1979a, p61). With rising water levels, the *Typha* swamps disappear from their original stands (as this sedge usually grows in water about 1m deep), but they reappear in areas previously occupied by marsh and floodplain grasslands. Similarly, marsh disappears where it becomes too heavily inundated, but it might develop on parts of the floodplains (Lancaster, 1979a, p27). The once extensive *Typha* stands between Chisi Island and the mainland north of Kachulu disappeared through drowning due the high lake levels in the late 1980s.
With rising lake levels, the area of open water increases considerably. As mentioned above, the area of open water at the mean level of 622m asl is set at 600km^2. In 1978, when the lake reached a record high (only to be surpassed by the high levels in the late

1980s), the surface area of open water was more than 1,500km² (National Water Resources Master Plan, 1986). The open water as seen on a satellite image taken in 1991, that is after some years with high rainfall and high water levels, covered an area of between 1,300-1,500km² (the distinction between water and mudflats on the photograph is not all that clear everywhere).

The results of the present study are in line with this. The calculations for open water, marsh and floodplains were based on maps from aerial photographs taken in 1989. The years in the second half of this decade were wet to extremely wet (Van Zegeren, 1998); consequently we find a very high value for open water (1,054km²), a high value for marsh (803km²), and a low value for the few floodplains left that are not inundated (220km²).

After some dry years in the early 1990s with below average rainfall, the Lake all but dried up in 1995. From January 1996, with the onset of the rains, it slowly started filling up again. This trend has continued over the past two years and an aerial survey by the author in September 1997 revealed that the total area of open water could be as high as 1,000km². This might seem a high value especially taking into account that after the drying up of the lake in 1995 water levels are still below average now. However, one should keep in mind that the extensive stands of *Typha*, which drowned after the high water levels in the late 1980s, have not yet been able to re-establish themselves, as the low rainfall in the first five years of the 1990s produced ever lower water levels.

Total size of the wetland

The difference in value for the total size of the Lake Chilwa wetland between the present study and the one carried out in the 1960s and 1970s, as reported in the *Lake Chilwa Monograph*, is less easily explained.

Whereas this study produced a total area of 2,325km², in the Monograph mention is made of the following figures in a year with an average lake level (Lancaster, 1979a, p19): 678km² open water, 578km² of swamps and marshes, and 580km² of seasonally inundated (floodplain) grasslands (which is roughly one-third water, one-third marsh and one-third floodplains: Kalk, 1979, p6). Including 14km² for the islands, this amounts to a total of 1,850km², which is at least 450km² less than what the present study found. Why this difference in total area between the previous and present studies? It has been difficult to establish the exact methods used to determine areas in the previous study, and to get relevant information from any of the researchers involved in this early study.

However, from the available literature, one gains the impression that the measurements were taken quite meticulously (Howard-Williams, 1979, p110; Maclachlan et al., 1972, pp 325-40). Howard-Williams and Walker (1974, pp 831-2), who give 700km² for open water and swamp each and an additional 500km² of marsh and grassland (amounting to a total of 1,900km²), indicate that these areas lie within the 3m raised terrace which delineated their study area. It might be that some of the areas included in the wetland in the present study lie outside that demarcation line (e.g. dambo grasslands along the lower course of rivers, which are continuous with the marshlands around the lake), but such areas are small and cannot explain away the difference found between the two studies. On the contrary, one would rather have expected a larger figure for total wetland area in the 1970s than in the 1990s, as parts of the floodplains and marshes have since been turned into arable land with either rainfed or wetland cultivation.

A careful study of the Monograph, however, reveals that not all authors contributing to the earlier study, apply the same area figures. See Table 2 for an overview.

In the introductory chapter of Kalk (1979, p6), a figure of 2,000km² is given for the lake surface alone at the end of the wet season when in flood, a figure higher than the total of 1,850km² for the total wetland given before. MacLachlan (1979b, p154), in a treatment of the faunal biomass in the three benthic habitats during a recovery phase of the Lake, gives figures for permanent swamp and temporary swamp (which actually is flooded floodplain in the first years of filling up of the lake) of 600km² and 80km² respectively. Compare this figure of 600 or 680km² for swamp alone with the figure of 578km² of marsh plus swamp given before (Lancaster, 1979a, p19)! Should we possibly have to distinguish areas of several hundreds of square kilometres for swamp and marsh separately?

Such a suggestion seems to be supported by the information provided by Cantrell (1979, pp 161-74) in his treatment of the major habitats in the swamp. Between lake shore and open water he distinguishes marsh, *Typha* swamp, swamp margins and lagoons plus channels (p164). For the different habitat areas he gives the following figures: 40km² for swamp margins, 600km² for *Typha* swamp, 390km² for marsh, and 60km² for the open water in lagoons and boat channels (Table 10.2 on p170). Using his data on swamps and marshes, we can calculate the total area for the whole wetland as follows: 600km² open water + 640km² *Typha* swamp + 450km² marsh + 580km² floodplains + 14km² islands = 2284km². This figure is almost the same as the total of 2,325km² arrived at in this study.

Table 2. A comparison of area sizes of Lake Chilwa's wetland and its components, as produced by different authors (in km²)

Origin of data	Note	Open water	Swamp	Marsh	Marsh and swamp	Flood plain	Total
Lancaster (1979a: p19), Lake Chilwa Monograph	1	678			578	580	1836, 1850
Howard-Williams and Walker (1974: pp 831-2)	2	700	700	—>		500	1900
MacLachlan (1979b:154)	3		680				
Kalk (1979:p6)	4	2,000					> 2,000
Cantrell (1979: pp 161-74)	5	600	640	450		580	2,284
Present study: data from 1990	6	1,054			803	220	2,325

Notes

1. These are the figures often quoted from chapter 2 in the *Lake Chilwa Monograph* (Kalk et al., 1979); the total of 1,850km² includes the islands.
2. The figure of 500km² stands for marsh and grassland.
3. Value for swamp alone 100km² higher than 'accepted' value for marsh and swamp.
4. A value of 2,000km2 for open water when lake in flood is higher than the usually accepted value of 1,850km2 for the total wetland. On the same page, this author mentions that in average years open water, swamps and floodplains occupy roughly equal areas.
5. Values of 600km² for open water and 580km² for floodplains not specifically mentioned in this chapter, as this study concentrated on the swamp areas. A value of 600km² for open water in an average year is however more often referred to, e.g. on pp 26 and 33 in the Monograph. Total value of 2,284km² includes 14km² islands.
6. Total value of 2,325km² includes wetland cultivation and islands.

These calculated totals also seem to be confirmed by the vegetation map of Lake Chilwa as shown in Chapter 7 of the *Lake Chilwa Monograph* (Fig. 7.1 on p111; Howard-Williams, 1979). On this map, swamp and floodplain are taking up the larger areas, and are of about equal size; while the marsh plus some transition swamp occupies an area of about one-half to two-thirds of the size of either swamp or floodplain.

Conclusion

Looking at all the different figures in Table 2 as a whole, it is clear that there is some discord among the different contributors to the *Monograph* as to size of the sub-divisions, as well as the total area of the wetland. This might partly have been caused by differences in opinion as to what to include in the different area measurements; there is also the possibility that the transformation from the imperial units of measurement to those of the metric system has contributed to the confusion. Whatever the reasons, we may safely assume that the total area of the Lake Chilwa wetland was under-estimated by some of the contributors to that study.

The figures found in the present study seem to be more realistic: a total area of 2,325km^2, or even 2,400km^2 (60 x 40km) for the whole of the Lake Chilwa wetland. Concerning the area sizes of the components of the wetland, the calculations made in this study were based on data from years (late 1980s, early 1990s) with above average lake levels (Van Zegeren, 1998); but the available information seems to indicate that for average, 'normal' years one could still apply the rule-of-thumb used in the *Lake Chilwa Monograph*: one-third open water, one-third swamp plus marsh, and one-third floodplains, resulting in 3 x 700 = 2,100km^2, plus around 200km^2 cultivated wetland.

One should, however, take note that in the last decade vast expanses of *Typha* swamp have disappeared, resulting in an increase in area of open water. If water levels would continue to raise in the next few years, one might expect a recolonisation of shallow open water areas by these bulrush stands.

Ackknowledgements

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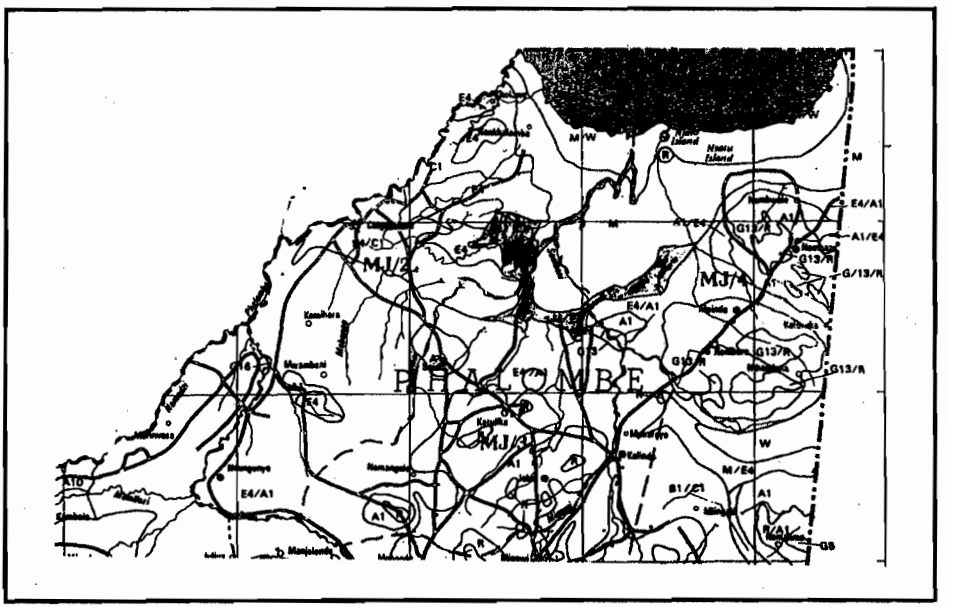
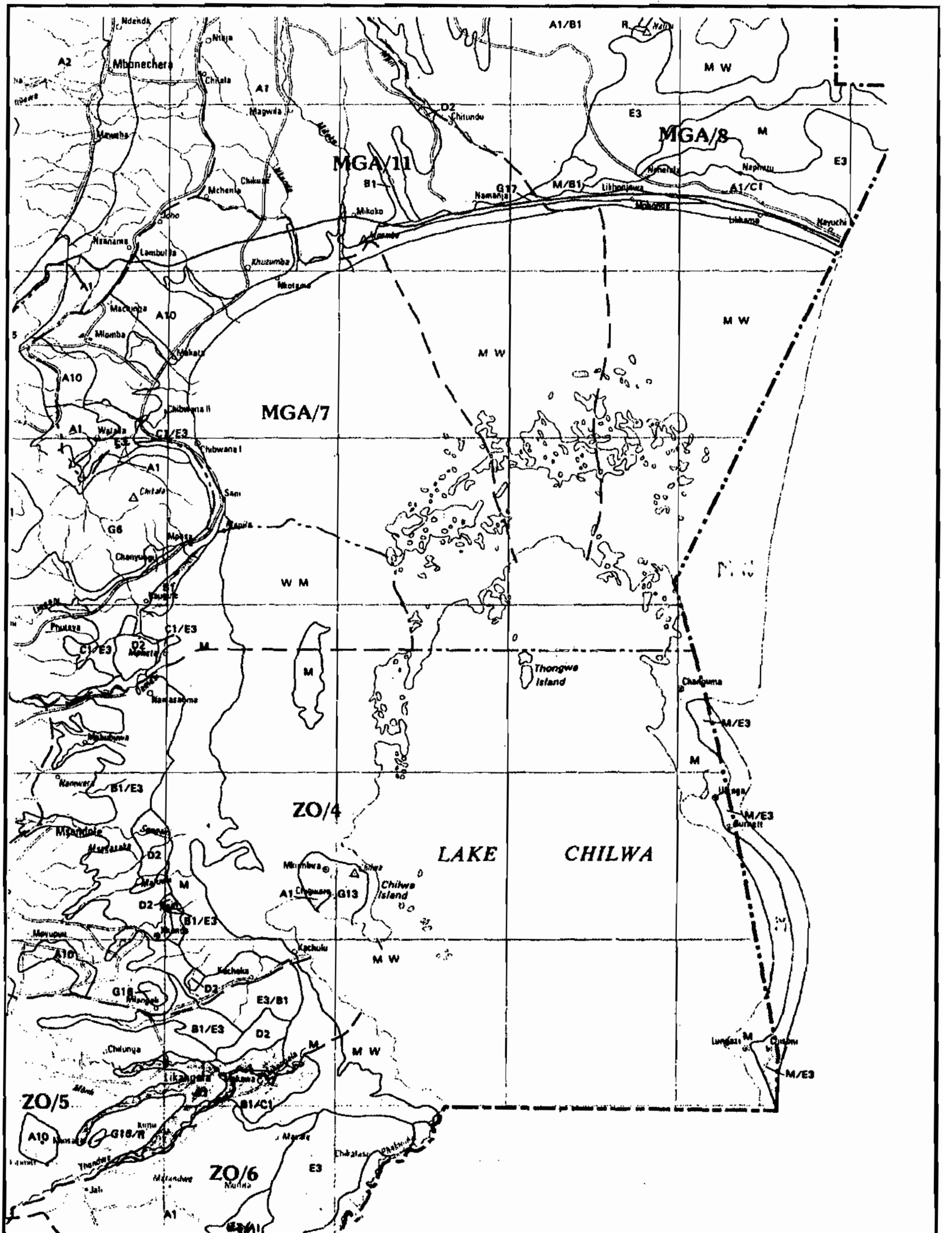
Annex: ADD Maps No. 4: Present Land Use and Vegetation, scale 1:250,000. Sections covering the Lake Chilwa Wetland

Relevant codes:

Open water	— no code	B1/C1	— wetland rice and dimbas
Water and marsh	— WM, MW	B1/E3	— wetland rice and floodplains
Marsh	— M	E3/B1	— floodplains and wetland rice
Floodplains	— E3	C1/E3	— dimbas and floodplains
Wetland cultivation	— B1	M/E3	— marsh and floodplains
Rice irrigation	— D2	E3/A1	— floodplains and rainfed cultivation

The ratio ratio 2/1 is used for all the 'complex' mapping units; further explanation is in the text.




MGA/11
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LAKE
CHILWA
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M W
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A1/B1
A1/C1
M/B1
C1/E3
B1/E3
E3/B1
M/E3
B1/C1
G16/R
G13
A10
D2
E3
M
A1
A2
G6