WATER RESEARCH COMMISSION

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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Wetlands & agriculture

Madumbe crops and their impact on wetland vegetation

A recently completed WRC-funded project investigated the impact of madumbe (*Colocasia esculenta*) cultivation on the evaporation of a *Cyperus latifolius* marsh in KwaZulu-Natal.

Madumbe – A potential wetland crop

The madumbe (*Colocasia esculenta*) is known as the 'potato of the tropics'. It is an important food plant in the hot regions of the world.

Madumbes are grown mainly for the underground, easily digestible, starchy tuber. The large elephant-ear-shaped leaves are also used as a type of vegetable. The madumbe is regarded as an indigenous plant, although it is thought to have originated from India over 2 500 years ago. It is one of the most widely grown traditional crops in Mpumalanga and KwaZulu-Natal, as well as in areas of the Eastern Cape and Limpopo provinces. Madumbes have a high soil water requirement and, under low rainfall conditions, farmers are very dependent on wetlands for madumbe cultivation.

If restricted to the less sensitive parts of the wetland, madumbe cultivation is reported to do little harm to the wetland. However, the impact of madumbe cultivation on the wetland water budget needs to be quantified in order to justify this claim. In addition, there are now plans to commercialise the cultivation of madumbes as part of a far-reaching empowerment scheme to support over 200 traditional subsistence farmers in KwaZulu-Natal. However, the extensive cultivation of this crop for commercial gain may have previously unrecognised negative impacts on *C. latifolius* wetlands, in particular. In turn, this may affect the sustainability of this venture.

Wetland hydrology: knowledge gaps

There remains a general lack of understanding of wetland hydrological processes in arid and semiarid areas. Yet comprehensive knowledge of wetland water budgets is needed to understand the functioning of these systems and to set appropriate management guidelines. Only a few studies have been conducted on wetland hydrology in the southern Africa region; these, for the most part, have focused on wetlands in the higher altitude interior of the sub-continent.

A key component of the water budget of a wetland is the loss of water to the atmosphere (also called evapotranspiration or *ET*), which may be strongly affected by the particular vegetation growing in the wetland. To date, very little research has been conducted on the *ET* of different wetland vegetation types occurring in South Africa, with a few exceptions such as *Phragmites* stands and swamp forests. Further studies on other wetland vegetation types commonly occurring in South Africa would be extremely valuable.

Traditional estimates of wetland *ET* using meteorologically based models can be highly variable with large degrees of error. Models that incorporate a crop coefficient for estimating *ET* have often been found to be inefficient, since for a wetland crop (e.g. *Phragmites australis*, the common reed) the *ET* rates have been found, in relation to standard reference rates, to vary by region and climatic conditions.

Clearly, errors can be introduced into these traditional models if crop coefficients do not account for different vegetation groups which have varying rates of water conductance which exert varying controls over *ET*. Additional influences on crop coefficients that need to be accounted for may derive from the shape and geographical extent of wetlands. Wetlands would tend to have higher *ET* rates when they are surrounded by areas with low *ET*, such as degraded grassland, than if surrounded by areas with higher rates of *ET*, such as forests (i.e. the oasis effect). Also, the extent and orientation of a wetland plays a part since wetlands such as riparian zones and marsh fringes around lakes would tend to have higher rates of *ET* than large expanses of wetlands with a greater area-to-perimeter ratio.

Wetland vegetation types in KZN

Cyperus latifolius marsh is one of the wetland vegetation types occurring most extensively in KwaZulu-Natal, the Pondoland region of the Eastern Cape and in the Mpumalanga and Limpopo provinces. *C. latifolius,* one of the sedges, has a C4 photosynthetic pathway, which is generally also an adaptation for water-stressed conditions. This suggests that it may have higher water use efficiency than C3 plants such as *Phragmites mauritianus* and swamp forest trees.

Madumbes have a high tolerance to water logging and are often cultivated in *C. latifolius* marshes. In assessing the potential impact of madumbe cultivation on wetlands, an important knowledge gap is the water loss from madumbes to the atmosphere, for which no studies have been undertaken in South Africa or elsewhere. For modelling these water losses using hydrological models, it would useful to have accurately and locally determined crop coefficients. To date no crop coefficients have been determined for madumbes.

Mbongolwane Wetland: an opportunity to study water use of wetland vegetation

The South African Sugar Research Institute has recently initiated long-term monitoring of the effects of different sugarcane management practices on runoff in the catchment of the Mbongolwane wetland, a large wetland near Eshowe, KwaZulu-Natal. The Mbongolwane wetland (approximately 3 ha) supports major stands of *C. latifolius* as well as extensive madumbe cultivation in the *C. latifolius* wetlands. Currently, the hydrological monitoring at Mbongolwane is confined to the catchment upslope of the wetland. Research on the effect of madumbe cultivation on the vegetation composition and geomorphology of the Mbongolwane wetland has already been undertaken; however no research on the hydrology of the wetland exists. This is recognised as an important gap.

Thus, it was suggested that a study on the *ET* of areas covered by *C. latifolius* and madumbes, together with monitoring of the water table in the wetland, would not only provide results that would be useful points of reference at a national and international level, but would also contribute valuable information to the integrated management of the Mbongolwane wetland and many other wetlands used in a similar way.

Quantifying *ET*

With the advent of techniques to accurately quantify *ET* from terrestrial and aquatic surfaces, the calibration of the traditional *ET* models for local conditions becomes possible. Direct measures of *ET* provide a means of accounting for local variations that models overlook. This approach has consequently been followed in a study to determine the impact of madumbe cultivation on the evaporation of a *Cyperus latifolius* marsh within the Mbongolwane wetland catchment. The aim of the study was to quantify the water use of three vegetation types: madumbes (*Colocasia esculenta*); sedge (*Cyperus latifolius*) wetland; and sugarcane (*Acer saccharum*) in the Mbongolwane wetland catchment. The study included two field campaigns carried out in November 2009 and January 2010 during the growing season of madumbes.

The approach used in the study to directly quantify *ET* of the various wetland vegetation types was to calculate *ET* as the residual term in the energy balance, with the other terms (principally net radiation, sensible heat flux and soil heat flux) being independently measured. Independent methods of determining sensible heat flux included the use of eddy covariance, scintillometry and surface renewal techniques. Special attention was given to obtaining high-quality data sets by meticulous attention to footprint analysis, fetch requirements, etc, to make sure of *ET* measurements being truly representative of targeted surfaces.

Results

The daily average *ET* rates in November 2009 were 3.5, 4.0, and 4.9 mm for the madumbe, sugarcane, and sedge sites respectively. The daily average *ET* rates in January 2010 were 3.3, 2.4 and 3.7 mm for madumbes, sugarcane and sedge, respectively. The daily total *ET* was therefore lowest at the madumbe site in November 2009 and lowest at the sugarcane site later in the season in January 2010. The crop coefficient, which relates the measured *ET* to modelled reference crop evaporation (ET_0) was found to be on average 0.6 for the madumbe's growth stage in both November 2009 and January 2010.

Conclusion

The information gained from direct ET measurements will be invaluable for future modelling of the water use of madumbes and the water balance of the wetland.

The madumbe plots were prepared by creating furrows and raising planting beds to increase water flow from the plots. This results in rapid drying of the plots and affects the water balance of the wetland during the madumbe planting and growing stages. It is recommended that long-term *ET* measurements, starting before the planting dates of madumbes, be undertaken to thoroughly investigate the effects of madumbe cultivation on the wetland. The unique set of high quality data already obtained will hopefully provide a basis for further studies on the impact of madumbe cultivation on wetlands.

Further reading:
To obtain the report, *The impact of madumbe (*Colocasia esculenta*) cultivation on the evaporation of a* Cyperus latifolius *marsh in KwaZulu-Natal* **(Report No: KV/260/10),** contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; E-mail: orders@wrc.org.za; or Visit: www.wrc.org.za