# Loss functions for sugar-cane: Depth and duration of inundation as determinants of extent of flood damage

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## Abstract

The paper aims to discuss the methodology used to develop loss functions for sugar-cane, with reference to the treatment of depth and duration of inundation as the main determinants of the extent of damage. The Mfolozi floodplain in Northern KwaZulu-Natal served as the study area. Loss functions for sugar-cane, for *ex ante* estimation of damage to harvests and crops, were developed for inclusion in a flood damage simulation model (FLODSIM) developed by the Department of Agricultural Economics of the University of the Free State in collaboration with the Water Research Commission. Depth of inundation was calculated in relation to the height of inundated sugar-cane in order to establish the extent of damage. Duration of inundation was taken into account by determining the maximum period of complete inundation after which the cane would be destroyed. Loss functions were determined for calculation of damage to harvests and damage to crops respectively.

## Introduction

The aim of this paper is to discuss the methodology used to develop loss functions for sugar-cane, with reference to the treatment of depth and duration of inundation as independent variables. The Mfolozi floodplain in the coastal region of Northern KwaZulu-Natal was used as study area. Loss functions for sugar-cane find its application in a flood damage simulation model for irrigation areas in South Africa (FLODSIM) developed by the Department of Agricultural Economics of the University of the Free State in collaboration with the Water Research Commission (Du Plessis et al. (1998). The economic impact of the 1996 floods on the structural flood mitigation measures and the sugar mill in the Mfolozi floodplain is discussed in Berning (1999).

In order to estimate flood damage with a simulation model, it is firstly necessary to identify relationships between characteristics of the flood and the extent of flood damage and secondly to quantify these relationships. The latter is done with the aid of loss functions. Du Plessis and Viljoen (1996) developed loss functions for vineyard, rotation crops and lucerne for *ex ante* flood damage determination in the Lower Orange River. They identified depth of inundation as the most important determinant of the extent of flood damage to the mentioned crops. With regard to sugar-cane, however, it was found that a strong relationship exists between the extent of flood damage and both depth and duration of inundation.

The paper sets out with a discussion of depth and duration of inundation. In the third section definitions of the different damage categories precede an exposition of the steps followed to determine loss functions for each of these categories. This is followed by a short discussion of the results obtained. Conclusions are given in the final section of the paper.

## Depth and duration of inundation

When the availability of oxygen to sugar-cane decreases for a sufficiently long period of time, as a result of partial or complete inundation by water or sediment, losses are suffered either because sugar-cane drowns completely (Weiss, 1976), or because of a decrease in sucrose content (Humbert, 1968).

Except when standing in stagnant water for prolonged periods, sugar-cane will not suffocate during periods of inundation provided the meristem and uppermost leaves of the plant extend above the water level (Rege and Mascarenhas 1965, referred to by Humbert 1968). Therefore with regard to sugar-cane, depth of inundation must be viewed in relation to the height of sugar-cane. A characteristic of sugar-cane areas is the great variation in the height of the cane which results from the harvesting season which extends from April till December each year. In order to determine, for every month of the year, the percentage area under cane of a specific height or lower, average monthly growth rates of cane in the floodplain were combined with the time of harvesting (Weiss, 1976).

Information regarding the area where sugar-cane has been completely inundated is, however, not sufficient to estimate flood damage. Even after complete inundation sugar-cane can still survive, given that the period of complete inundation is short enough. Thus it was necessary to determine the critical or maximum period of complete inundation after which the cane would be destroyed. According to cane farmers in the Mfolozi floodplain the minimum period of inundation before sugar-cane is completely destroyed, varies between approximately three days during warm months and six days if the flood occurs during cold months. Damage to sugar-cane increases if flooding occurs during warm conditions because plants have relatively higher water and nutrient requirements than during winter (Humbert, 1968). For purposes of flood damage simulation, sugar-cane which had been completely inundated for longer than three days, was considered destroyed if floods occurred during any month from November until April. From May until October the critical period was taken as six days. Hence the area of sugar-cane of different heights which is totally destroyed during the flood, could be determined. In the case of immature sugar-cane, the productive value was taken as the ratio of the true height of damaged sugar-cane, to the average height of mature sugar-cane (Weiss, 1976).

The hydraulic simulation model Mike 11 was used to simulate the flow of water through the Mfolozi floodplain and to supply

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