

Loss functions for structural flood mitigation measures

C Berning, LA Du Plessis* and MF Viljoen

PO Box 339, Department of Agricultural Economics, University of the Free State, Bloemfontein, 9300

Abstract

The paper aims at discussing the methodology used to develop loss functions for flood mitigation measures, using historic data of flood damage to infrastructure. The main determinants of the extent of damage are the size of the flood and the length of the infrastructure within the boundaries of the flood-line. In regression analysis, flood peak was used as the independent variable in the Cobb-Douglas functions to depict the relationship between damage and flood peak. The Mfolozi flood-plain in Northern KwaZulu-Natal served as the study area. Loss functions for infrastructure, for ex ante estimation of damage to infrastructure, were developed for inclusion in a flood damage simulation model (FLODSIM) developed by the Department of Agricultural Economics of the University of the Orange Free State in collaboration with the Water Research Commission. Loss functions were determined for spillways, levees, tramlines, public roads, drains and bridges.

Introduction

The aim of this paper is to discuss the methodology used to develop loss functions for infrastructure to determine the potential flood damage to infrastructure (spillways, levees, tramlines, public roads, drains and bridges) before floods occur. Loss functions define the relationship between flood damage and certain characteristics of a flood. Flood damage to infrastructure is assessed as the cost of repairing infrastructure to that of pre-flood conditions. The two most significant factors that determine the extent of flood damage are the size of the flood, in terms of volume of water that flows through the flood-plain, and the length of roads, drains, and other structures, within the boundaries of the flood-line. Cobb-Douglas functions were used to depict the relationship between flood peak and damage to infrastructure. The Mfolozi flood-plain in the coastal region of Northern KwaZulu-Natal was used as a study area. The Mfolozi co-operative bears the cost of repairing spillways, levees and tramlines, as well as public roads, drains and bridges. The cost of repairing private roads, drains and bridges, for which farmers are responsible, was not included in the loss functions for infrastructure presented in this article. The loss functions for infrastructure were included 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 paper commences with background information on the infrastructure found in the Mfolozi flood-plain and the causes of damage to the infrastructure. In the third section the steps that were followed to determine loss functions for infrastructure are given. This is followed by a short discussion of the results obtained. Conclusions are given in the final section of the paper.

Infrastructure in the Mfolozi flood-plain and the causes of damage

The transportation network includes roads, bridges and tramlines. Farmers' houses in higher areas are linked to farms in the flood-

plain by approximately 70 km of gravel roads. The co-operative is responsible for maintenance and reparation of approximately 34 kilometres of roads. Several bridges, such as the Domoina-, Wilson's Cannal-, 31/2-, Low Level- and Monzi Bridge, are also maintained by the co-operative. A tramline network of 92 kilometres is used for transporting sugar cane to the mill. Annually, the network transports more than 650 000 tons of sugar cane to the mill over an average distance of 16 km (Department of Environmental Affairs, 1986). The marshalling yard lies to the north of the Mfolozi River and it is to be expected that there will be limited damage only in the case of large floods (Bosch and Associates, 1995).

The water related works include levees, spillways and drains. Levees, with an average height of 3 m, are maintained to prevent inundation caused by the overflow of the banks of the Mfolozi River and the resultant damage to farms. For the area where farms border the river, the whole South Bank and the largest part of the North Bank of the Mfolozi River, have levees. Besides the levees on a large part of the northern bank of the Msunduzi River, there are also the Mavuya and Mokana Banks and the levees on both sides of the Jump Estate and Wilson's Channel. After the flood, the drainage network facilitates the removal of water from the farms. A drainage network of approximately 115 km drains storm water from farms in the flood-plain to the Mfolozi and Msunduzi Rivers (Department of Environmental Affairs, 1986). Farmers are responsible for private drains of approximately 32 km, while the remaining 83 km are maintained by the co-operative (De Jager, 1997). There are two spillways carrying surplus floodwater of the Mfolozi River to the Msunduzi River to prevent overflowing of the main bank of the Mfolozi River. The length of the emergency spillway is 120 m. The longest spillway, which was completed after the Domoina flood of 1984, is 1 000 m (Department of Environmental Affairs, 1986). The purpose of the spillway is to channel the floodwater evenly over sugar cane fields in the direction of the Msunduzi River. Furthermore, the spillway also decreases the speed whereby floodwaters flows across the flood-plain and less sand is carried by the water and deposited on low-lying farms. The spillway starts functioning when discharge exceeds approximately 760 m³/s, i.e. when the flow of the Mfolozi River reaches the level of the spillway. As the flow increases, a portion of the flow is released over the spillway to the Msunduzi River and onto the flood-plain. The ratio that is diverted becomes greater as

* To whom all correspondence should be addressed.

☎(051) 401-2721; fax (051) 448-0692; e-mail: anton@landbou.uovs.ac.za
Received 10 December 1998; accepted in revised form 4 September 2000.