

# Determining the benefits of flood mitigation measures in the lower Orange River: A GIS application

LA du Plessis\* and MF Viljoen

Department of Agricultural Economics, University of the Orange Free State, PO Box 339, Bloemfontein, South Africa

## Abstract

When topographical, hydrological, hydraulic and economic information is integrated with the aid of a flood damage simulation model, the total mean annual flood damage can be estimated. With the total mean annual flood damage known, it is possible to ascertain the benefits of several flood mitigation measures. These measures are normally implemented to reduce the physical extent of floods, relieve the effect of a flood on humans and the community and reduce the tendency toward flooding in different areas. It is not economically justified to implement measures to such an extent that they will prevent the total risk of flood losses. The benefits gained from flood mitigation measures should at least exceed the costs involved. Consequently, an optimal package of flood mitigation measures should be compiled where the marginal benefits are equal to the marginal cost.

The purpose of this paper is to identify relevant flood mitigation measures for the research area, discuss their benefits and drawbacks, after which the possibilities for application in the research area are analysed.

## Introduction

When one develops a flood damage simulation model, it is possible to integrate flood damage functions, topographical, hydrological, hydraulic and economic databases in order to establish the total direct flood damage. This process can be repeated for various floods with different probabilities of occurrences. With these results it is then possible to calculate the mean annual damage (MAD). With the MAD known, it is possible to calculate the benefits of different flood mitigation measures for any area of investigation. Flood mitigation measures can be implemented to reduce the physical extent of flooding, relieve the effect of a flood on humans and the community and reduce the tendency towards flood damage in different areas. They can also be implemented to reduce the risk of flooding and in this way, income stability can be assured at farm level (Van Zyl and Groenewald, 1984a). Krutilla (1966) points out that, in spite of the disastrous effects of flooding, it is not economically viable to implement measures to such an extent that they will prevent the total risk of flood losses. This is because the cost of the flood mitigation measure will exceed the benefits thereof. Keeping the above-mentioned in mind, an optimal package of flood mitigation measures, can be compiled where marginal benefits are equal to the marginal costs.

Before an optimal set of flood mitigation measures can be established for an area, the different measures which can be implemented should first be identified. After that, it is necessary to indicate for each measure exactly what it entails and what its benefits and costs will be. After the benefits and costs of each measure have been established, suitable packages can be identified for the research area. An optimal flood control and flood damage control measures package can then be compiled.

Against this background, the paper only focuses on the first two steps, namely identifying applicable flood mitigation meas-

ures for the research area and estimating the total benefits and cost of the different flood mitigation measures with the aid of a flood damage simulation model (FLODSIM) based on a GIS approach. Due to the fact that the procedures of calculating the different flood damage categories (Du Plessis and Viljoen, 1997; 1998) and also the procedures followed by FLODSIM (Du Plessis, 1999) are already published, no further attention will be given in this paper to the above-mentioned.

## Theoretical framework

Flood mitigation measures are divided into three categories (Fig. 1), according to Higgins and Robinson (1981). Handmer (1985) and Viljoen (1979) use the same classification. Although the order is changed, the same basis of classification is used.

The first measure is concerned with the control of flood waters, namely keeping flood water out of developed floodplains. For this purpose, structural measures like flood control dams and levees are usually used. Secondly, damage can be reduced in areas with the greatest flood damage potential by limiting settlement and development in these areas. This usually entails non-structural measures, like land-use regulations. Lastly, measures are associated with the risk actions by the inhabitants of floodplains, in accordance with and overlapping the first two measures. A very important component of this is comprehensive public education and information programmes.

## Evaluation of flood mitigation measures

The effect of several flood mitigation measure options on potential disasters and damage is graphically depicted in Fig. 2 by specifically referring to the benefits of different flood control options and disaster potential. The probability of disaster potential can be reduced through some flood mitigation measures or risk-reducing options, while other measures increase the potential for disaster. Apart from the disaster potential, some flood mitigation measures can be advantageous to the local and/or national community, while others have detrimental effects.

\* To whom all correspondence should be addressed.

☎ (051) 401-2721; fax (051) 401-2721; e-mail anton@landbou.uovs.ac.za  
Received 30 March 1997; accepted in revised form 27 November 1998.