

Flood damage estimation - A review of urban stage-damage curves and loss functions

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Abstract

The estimation of damages is integral to the formulation of flood policy. For the assessment of flood losses this requires the use of stage-damage curves for different classes of buildings. A review is presented of the methods used to construct these. The use of synthetic techniques is stressed and attention given to actual and potential losses and to the susceptibility of buildings to failure in response to floodwater depth and velocity. Recommendations are presented for the construction and use of stage-damage curves for residential and commercial buildings in South Africa.

Introduction

The Department of Water Affairs and Forestry is currently engaged in formulating a National Flood Policy for South Africa. A key element in such a policy is the assessment of flood damages for both the rural and urban sectors. This is necessary in order to weigh the costs of flood mitigation measures against the benefits of reducing flood damage. This account reviews research on stage-damage curves to evaluate urban losses and presents guidelines for their use in South Africa.

The basic methodology is dependant upon the development and use of stage-damage curves, alternatively called "loss functions". These were outlined by Gilbert White some 50 years ago (White, 1945; 1964). A stage-damage curve normally relates to a specific class of building or crop and presents information on the relationship of flood damage to depth of flooding (or stage). Stage-damage curves are the essential building blocks upon which flood damage assessments are based.

This review considers:

- the development of the concept of stage-damage curves;
- problems in constructing such curves; and
- recommendations for South Africa.

The development of the concept

Stage-damage curves were developed in order to predict flood losses. The initial response was to gather data from actual flood events and use these as a guide to future events. There are a number of problems with this approach. Extrapolation from place to place poses difficulties due to:

- differences in warning time; and
- differences in building type and contents.

Even at a single location, for floods of comparable magnitude, there are differences. A key reason is the prior flood experience of the community. Compounding the problem is that detailed damage surveys after major floods are uncommon and often rely

upon the analysis of relief payments, insurance pay-outs or, worst of all, newspaper accounts of damage.

Extrapolation and prediction of flood losses, as an input into benefit/cost analysis, requires a different approach to the use of actual damages from a past flood event. White (1964) was the first to suggest a new methodology which for the purposes of this account can be termed "synthetic". Synthetic stage-damage curves do not rely on information from an actual flood event but are based on hypothetical analysis. The approach provides stage-damage curves for differing land uses, specifically building types and uses.

The skill in obtaining synthetic loss functions is to decide on the number of building types to be included. This represents a trade-off between time expended and accuracy. An accepted and standardised methodology is required. This is necessary in South Africa as an essential component of a national flood policy.

The first major application of standardised stage-damage curves to buildings was for use with the National Flood Insurance Act (1968) in the USA, administered by the Federal Insurance Agency. This involved the US government in providing financial backing for flood insurance for established residential buildings located in flood-prone areas (below the 1 in 100 year flood line). Houses were divided into insurance classes, each with their own stage-damage curves, based on size, type of building (construction material, number of storeys, presence or absence of a basement), contents etc. The stage-damage data were, however, presented in terms of market value. Examples of the rating tables are given in HUD (1970).

This approach is not recommended as there is a relatively poor relationship between the market price and susceptibility to flood damage. Loss is restricted to the buildings and its contents, land price is extraneous. Although stage-damage curves are internationally accepted as the standard approach to assessing urban flood damage there are relatively few published accounts that give details of the methodology for their construction or their application. Examples in the literature are mainly from North America, the UK and Australia.

Penning-Rowse and Chatterton (1977) produced a *Manual of Assessment Techniques* which provided detailed synthetic stage-damage curves for both residential and commercial property in the UK. These data are extensively used to assess flood damage there and provide an essential input into computer programs designed to evaluate flood mitigation options. The data have been revised and are available in Parker et al. (1987).

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