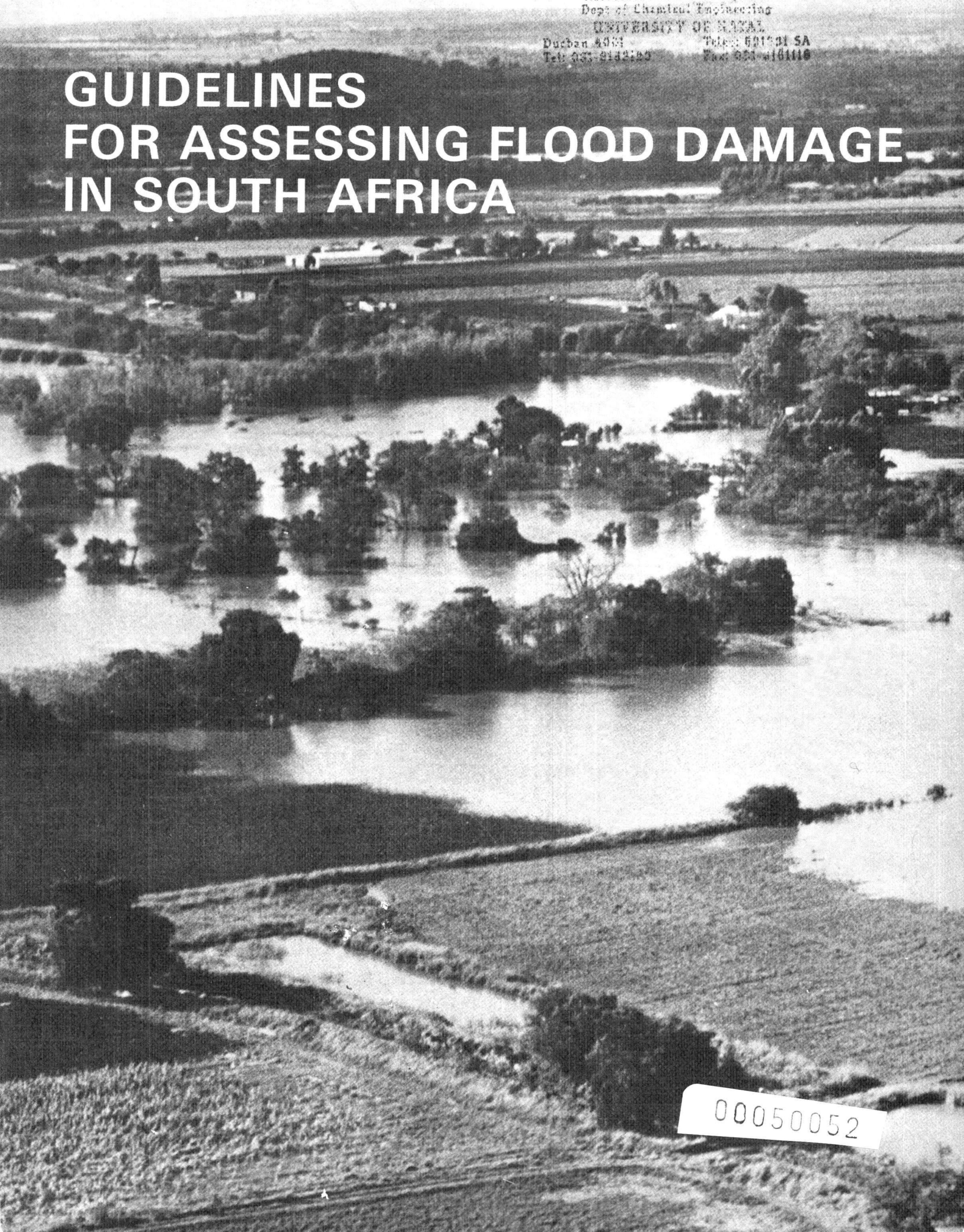

GUIDELINES FOR ASSESSING FLOOD DAMAGE IN SOUTH AFRICA

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GUIDELINES FOR ASSESSING FLOOD DAMAGE IN SOUTH AFRICA

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CHAPTER 1

INTRODUCTION

On the average, floods causing damage on a relatively large scale occur once every two years in South Africa. Many flood plains are occupied by intensive irrigation land. Urban and industrial development, as well as telecommunication and transportation services are also situated in flood plains. This penetration of human activities into the flood plains causes economic and community disruptions, with sometimes even wider national implications, when a flood occurs. Moreover, a diversity of economic and physical characteristics in different river reaches complicates forecasting flood damage for policy purposes. The degree to which a specific reach in a river is prone to flood damage will *inter alia* be determined by the occupational pattern, as well as the topographical, geological and hydrological characteristics of the reaches.

Given the present trends in the occupational pattern of flood plains in South Africa, it should be clear that the occurrence of floods could make progressively higher demands on aspects such as planning and control of both the floods and the utilisation pattern in these flood plains. The major floods on a country-wide scale during 1974 presented an ideal opportunity for research on the subject. The Directorate of Water Affairs therefore requested the Water Research Commission to initiate research on the impact of these floods and to assess the flood damage. This research was later extended to include the assessment of damage due to a major flood in the Vaal River during 1975.

Research of this kind had not previously been undertaken in South Africa and no bibliographical source regarding the assessment of flood damage on a comprehensive scale was available. The initial task of the research team was, therefore, to construct a theoretical basis upon which a methodology for flood damage assessment could rely. Only after this was completed, and the methodology spelled out, could the actual research with respect to flood damage assessment be conducted. The purpose of this publication is to give a resumé of the completed research with the accent on guidelines for flood damage assessment in an *ex post* context. However, any person intending to conduct similar investigations, is warned not to regard the material presented as a final recipe, as practical problems will always be encountered and these should be solved by the logic underlying specific situations. Extensive use was made of the five research reports submitted to the Water Research Commission and any prospective researcher is referred to these reports for careful and critical study before venturing into this field. The following reports were submitted:

- Spies, P.H., Viljoen, M.F. and Smith, D.J.G. *Vloedskade in sekere riviertrajekte van die Republiek van Suid-Afrika, Deel I — 'n Metodologie vir vloedskadebepaling.* Pretoria, Water Research Commission, 1977.
- Spies, P.H. *Vloedskade in sekere riviertrajekte van die Republiek van Suid-Afrika, Deel II — Bevindings rakende vloedskades in drie riviervalleie in die Noord-Westelike en Oostelike Kaapprovinsie.* Pretoria, Water Research Commission, 1977.
- Viljoen, M.F., Vos, J.A. and Marais, P.J. *Vloedskade in sekere riviertrajekte van die Republiek van Suid-Afrika, Deel III — Bevindings rakende die 1974 vloedskades vir verskillende riviertrajekte van die Oranje-, Vaal-, Riet-, Seekoei-, en Hartbeesrivier.* Pretoria, Water Research Commission, 1977.
- Viljoen, M.F., Smith, D.J.G. and Spies, P.H. *Vloedskade in sekere riviertrajekte van die Republiek van Suid-Afrika, Deel IV — 'n Evaluering van die problematiek rondom vloedskadebepaling in die Republiek van Suid-Afrika.* Pretoria, Water Research Commission, 1978.
- Viljoen, M.F., Vos, J.A., Smith, D.J.G., and Prinsloo, J.W. *Die 1975 vloedskade vir verskillende trajekte van die Vaalrivier.* Pretoria, Water Research Commission, 1980.

CHAPTER 2

CONCEPTS AND MODELS IN FLOOD DAMAGE ASSESSMENT

In this chapter certain basic concepts relevant to flood damage assessment (FDA) are presented. Although some of them appear to be self-explanatory, they could nevertheless lead to divergent interpretations in practice.

2.1 FLOOD

Broadly speaking a flood may be divided into a land and a channel phase. During the land phase water flows over the land when the intensity of the rainfall exceeds the infiltration capacity of the soil. When this run-off reaches the rivers (causing an above normal flow), and the banks of the river are overflowed, the channel phase of the flood comes into existence (Hoyt and Langbein, 1955). Only the channel phase is relevant for purposes of this discussion.

Floods vary in size. For planning purposes this variation is normally expressed in terms of the period of recurrence (the so called reference flood), for example a one-in-hundred-years flood or a one-in-fifty-years flood. The period of recurrence refers therefore to the probability of a specific flood.

2.2 FLOOD PLAINS

The low-lying regions bordering rivers, which are normally dry but become inundated during floods, are referred to as flood plains. The area of these flood plains will be determined by specific reference floods. Thus, a one-in-hundred-years flood will give rise to a larger flood plain in a specific reach than say a one-in-twenty-years flood.

2.3 FLOOD DAMAGE

Flood damage can be described as the material and intangible losses suffered by a community on account of a flood. The material or tangible losses refer to damages which can be enumerated in monetary terms, whereas the intangible damages denote thát portion of the losses that cannot be enumerated in this way (Eckstein, 1958, pp. 127—141).

Tangible losses are normally subdivided into primary and secondary losses (see Figure 2.1). Primary damages denote first order effects while secondary damages denote effects of the second and higher order; i.e. a multiplier effect. Primary damage can furthermore be subdivided into direct and indirect damages. Damages are direct when the damaged entity has made physical contact with the flood water and indirect where no physical contact was made (James and Lee, 1971, pp. 250—255). Indirect damages include effects which occur over a period of time, or effects which are spatially removed from the flood regions, or a combination of the two.

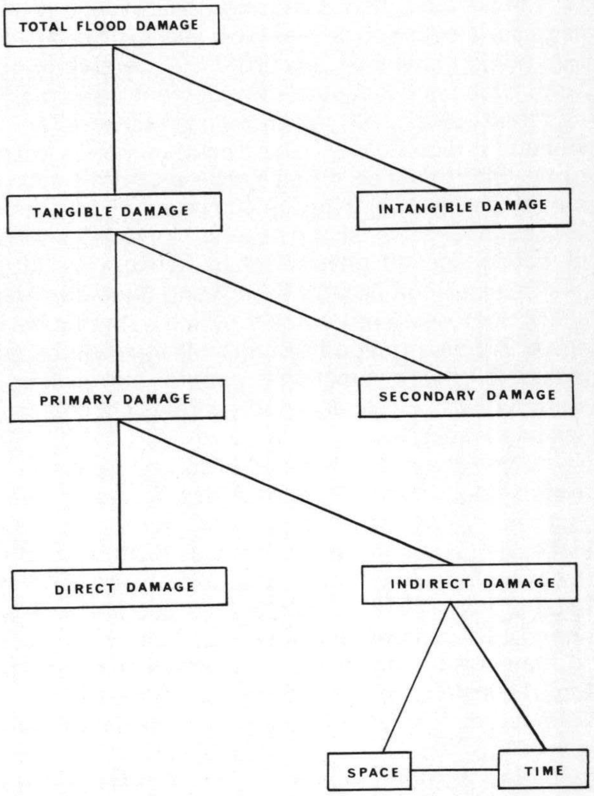

Figure 2.1: Classification of flood damages

Some researchers prefer to classify secondary losses under indirect damages (Skowyrski, 1976, p. 4). As will be pointed out later in this report, distinction was made between secondary losses and indirect damages. Apart from the above-mentioned damage categories, American researchers identified an additional group, namely uncertainty losses (Grigg, *et al.,* 1975). These losses are suffered by the inhabitants of the flood plains on account of the continuous uncertainty regarding the time of occurrence of the next flood and its intensity. These types of losses have two components, namely that accruing from the feeling of insecurity (which is intangible) and thát due to the non-optimal utilisation of the flood plain (which is tangible).

2.4 FACTORS WHICH MAY DETERMINE THE DAMAGE POTENTIAL OF FLOODS

Factors related to the nature of floods, the potential impact of floods on human activities and the measuring of

Rainfall in catchment area causes a specific land phase flood depending on:

Exogenous variables
(1. Size of catchment area;
(2. Distribution of rain over catchment area;
(3. Distribution of rain over time;
(4. Intensity of individual storms
(5. Hydrological and topographical characteristics of catchment area.

A specific land phase flood determines the volume of water per second that will reach the river at a certain point.

Qualifying

Characteristics of river comprises:

Parameters
(1. Topographical qualities, such as slope, width of river channel, width of flood plain, topography of flood plain and adjacent areas;
(2. Hydrological qualities, such as meandering characteristics of river and obstructions in flood plain or river channel;

Exogenous variables
(3. Geological qualities, such as factors that enhance soil or bank erosion, and thus also sediment content of the river.

A specific volume of water in a specific reach in a river determines the nature, extent and quality of the flood in the reach. The flood is defined in terms of:

1. Momentum flux (a function of discharge, density and velocity of the flood waters)
2. Flood stage
3. Flood duration depicted in a flood hydrograph
4. Sediment content of the flood water in parts per million
5. The time of the year, month, week or day of the flood.

A specific flood in a reach can result in flood damage depending on:

Parameters
(1. The position of human activities in the flood plain;
(2. The type of human activities in the flood plain at a certain time;
(3. Flood control (structural) and — management practices (non-structural) in the flood plain.

Figure 2.2: Relationships, variables and parameters that are causal to flood damage in a specific reach.

this impact may be interpreted differently by researchers. In order to point out the problems that may arise, some characteristics of these factors are now discussed.

From a planning point of view flood damage may be looked upon as a stochastic rather than a deterministic occurrence. The stochastic nature of flood damage is primarily connected with the expected incidence of storms during the course of a year and the distribution of these storms over the catchment area of a river (Hoyt and Langbein, 1955). The nature and magnitude of floods accruing from these storms are dependent on a diversity of factors some of which can be influenced by man, while others are beyond his control. Some of the relationships regarding flood damage are shown in Figure 2.2. Those factors that are generally beyond the control of man are denoted as "exogenous variables" and those which could possibly be controlled as "parameters".

Depending on the hydrological and topographical characteristics, as well as the size of the catchment area of a river, a rain storm of specific duration, distribution and intensity will cause a wide range of flood responses depending upon the state of the catchment area at the time, i.e. the wetness or dryness. A flood can be described in terms of momentum flux, depth of flow, duration of high stage and sediment content of the flood waters. It is the change of momentum flux that gives the measure of the force with which the flood waters can sweep away obstructions.[1] Stage is the elevation of the water above a datum and thus defines the depth of inundation at any point in the flood plain. A flood hydrograph illustrates the flood stages as a function of time, while the sediment content may be indicated in parts per million (ppm) or milligrams per litre (mg/ℓ). All these characteristics of a flood can influence the nature and magnitude of the resulting flood damage.

The force associated with flood waters of given magnitude and sediment or debris content will cause damage to a greater or lesser degree depending on the nature and scale of human activities in the flood plain. These activities may differ with respect to their location in the flood plain, the kind of activity (for instance farming or industrial), time (time of the day, week, month and season) and flood control practices.

Flood damage will therefore vary in accordance with related exogenous variables, as well as to the extent that specific parameters are manipulated. These factors may impede comparability and the ability to generalise from the available flood damage data. For instance, a stage damage curve (depicting the relationship between damage and depth of inundation) derived for one river reach, may not be at all relevant for the next one.

---

1 Force is equal to change of momentum flux

i.e. $F = Q \varrho \Delta V$

where F = force in newton

Q = discharge in cubic metres per second

ϱ = mass density of the flood waters (kilograms per cubic metre)

ΔV indicates the change of velocity in magnitude or direction (or both) associated with, for example, an obstruction.

The force exerted on an obstruction can also be expressed thus:

$$F = \tfrac{1}{2} \varrho V^2 A C_D$$

in which A is the projected area of the obstruction normal to the direction of V, the velocity of the flood waters averaged over the area A. C_D, the coefficient of drag, has a value of the order of 2,0, unless the obstruction is streamlined in which case lower values would hold.

CHAPTER 3

AN APPROACH FOR FLOOD DAMAGE ASSESSMENT

3.1 THE ROLE OF WELFARE ECONOMICS

Welfare economics is the theory of how and by what criteria economists and policy makers make or ought to make their choices between alternative policies and between good and poor institutions (Arrow and Scitovsky, 1969, p. 1). More particularly, welfare economics provides an analytical basis for decision making by public authorities. In this instance studies in applied welfare economics may be utilised in order to give *inter alia* guidelines for an approach to management and planning problems such as taxation, subsidies, project development, reallocation of wealth and economic growth (Arrow and Scitovsky, 1969, pp. 521–615). It is clear that an investigation of flood damage could fall within this framework, and that welfare economics could supply a framework within which a methodology for flood damage determination can be formulated. An understanding of some of the principles of welfare economics develops an awareness (sensitivity) to the preconditions of flood damage assessment. In this chapter a few arguments from welfare economics are presented in order to explain certain fundamental principles of cost-benefit analysis and flood damage assessment.

3.2 THE PROBLEM OF PRICING AND SOCIAL CHOICE

Two problems which are basic to analysis in welfare economics are correct pricing and social choice, i.e. establishing a social rank ordering of priorities. Many of the pricing problems in project evaluation are associated with public goods, free goods and monopolies (or state intervention). Another problem is related to the fact that the market prices represent average prices and that these cannot therefore be used to enumerate the impact of economic changes without at least some minimal attention to the broader environment surrounding these changes. Compounding this problem is the fact that at least some project evaluations require an understanding of social priorities. These problems are discussed in this section.

3.2.1 Some factors in pricing costs and benefits: public goods, free goods and managed pricing

It is obvious that goods and services are in practice not always allocated by the free market system. Certain types of goods and services are classified as collective (public) goods and are partially or completely dissociated from the free market system. Examples of these are parks and roads on river banks. In other cases goods and services are supplied by monopolies or more generally within the framework of monopolistic competition. In these cases price structures may differ considerably from the equilibrium free market prices.

Government often intervenes in the price structure with, for instance, subsidies on irrigation works, fertilizer and other production factors as well as on products. Free market price formation is disturbed by such intervention. Prices which figure in the assessment of flood damages may therefore incorporate government decisions which should preferably be handled separately. For the purpose of this report it is assumed that the administered prices include social preferences. This, however, should not be accepted axiomatically for all projects. Certain projects may have large price distortions in which case the researcher should rather resort to shadow (synthetic) pricing (Gittinger, 1972).

Another imperfection in the logic underlying the free market system is that it assumes all resources to be fully employed, in other words, that no unemployment or under-utilised resources exist (Baumol, 1965). This is clearly a general problem in the analysis of public projects. If under-utilised resources can be identified a notably lower price than the market price for fully utilised resources should apply.

Another complication in pricing surrounds the so-called "free" goods and services of society. For instance in the case of sunshine, the air which is inhaled or beautiful scenery, no private ownership exists and it is therefore not possible to attach a "market" price to these services.

3.2.2 Economic interactions and externalities

An understanding of the working of the general equilibrium system of an economy could be of help in the interpretation of some aspects of the economic process to the planner for three reasons. Firstly, the nature of the relationships and interdependence between different participants in an economic process is highlighted. This interdependence underlines the need to analyse the wider impact of a flood when it is of such a magnitude that it could likely cause disturbances in the national economy. Secondly, it creates an appreciation for the central function of the price system in a free market economy. The price system is the result of competition, accruing from scarcities and human needs. It is therefore not completely correct to measure changes in welfare directly through changes in magnitudes which were solely based on market prices. A more careful evaluation of the role of prices will show that they are dependent variables. It should therefore only be used with great caution in the assessment of flood damages.

Thirdly, beside the already mentioned interactions in an economic system, another group of interactions exist which are totally or partially dissociated from the market system and are therefore not described within the general equilibrium system. These interactions are known as externalities and include both external cost and external benefits. One example of an external cost is pollution where the production or consumption activities of one entity have a detrimental effect on the production or consumption activities of another.

Another example is the consequences of the construction of buildings or bridges within a flood plain. These structures may hamper the natural flow of the flood water by diverting the water to areas which are normally not flooded. The costs associated with these floods (i.e. outside the normal flood plain) are external costs.

3.2.3 The measurement of the consumer surplus[1]

Another potential problem associated with the use of market prices in damage assessment, is the exclusion in estimates of the loss in the so-called "consumer surplus". To illustrate this point, suppose a certain group of consumers in a flood plain consumed OQ_1 goods and services at a price OP_1 before a flood (Figure 3.1). As a result of the flood the available quantity of goods and services is reduced to OQ_2. If damage calculation is based only on market prices and quantities and these prices of the goods and services are held constant, (say by government measures), the total damage will be equal to area (5) in Figure 3.1. However, actual damages include the loss in consumer surplus. It is in fact larger than area (5), namely areas (5) plus (3). Area (3) is the loss in consumer surplus, under the assumption of prices being constant, whereas area (5) represents the loss in economic rent.[2] This will also be the total tangible loss should the price of the goods and services rise to P_2, since area (2) is not a social loss but only a transfer of income in favour of the supplier (producer) of the goods and services.

3.2.4 Establishing a rank ordering of social preferences

A rated classification of objectives is essential for the planning and development of government projects since it is often possible to recommend various projects with equal economic viability. The choice between these projects depends largely on value judgements and unless the public sector supplies the necessary value judgements, the planner is compelled to use his own norms when making recommendations. Such a situation is undesirable because there is no rule which necessitates that the planner's judgement will coincide with that of the community. This matter will be elaborated on in the subsequent discussion on cost-benefit analysis.

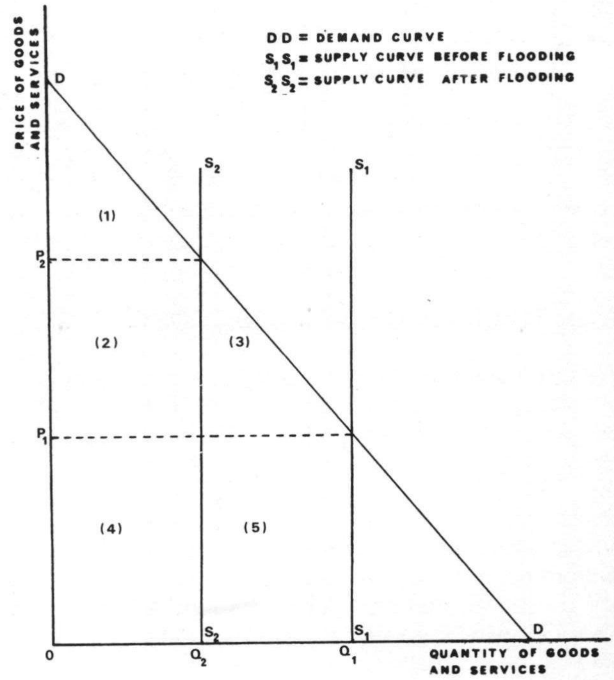

Figure 3.1: Demand and supply curves of goods and services for the determination of the social cost of floods.

3.3 COST-BENEFIT ANALYSIS

Cost-benefit analysis will be discussed as an application of the principles of welfare economics. It is not the aim to discuss all aspects of cost-benefit analysis here but only to draw some guidelines for the assessment of flood damage.

An important problem in cost-benefit analysis is choosing the benefits and costs to be included and establishing how they should be measured. In addition, in the case of long term effects, choosing an appropriate discount rate is of the utmost importance. As was mentioned previously, welfare economics can contribute to a clearer understanding of the problems underlying the measurement of these effects. The imperfections of market prices as a criterion of value, as well as the uncertainty in respect of the inclusion and measurement of externalities, secondary effects and intangibles are cases in point.

A few of the most important problems in the application of cost-benefit methods to flood damage assessment will be discussed in the next two chapters. The implications of time and a social preference scale (referred to

1 Marshall defines the consumer surplus for the first time at the beginning of the 20th century as the additional price a consumer would be willing to pay for a small unit of the goods and services he consumes when faced with the possibility of losing it (Marshall, 1920). By this definition the consumer surplus is the difference between the area below the demand curve (Figure 3.1) up to the quantity consumed, and the total expenditure to buy that quantity.

2 In the case of a supply curve other than the total inelastic one of Figure 3.1, the economic rent could be subdivided into producer surplus and production cost. The producer surplus is the difference between the price received for each small unit produced and the minimum price necessary for production to continue.

as a "social welfare function") on the assessment of flood damage will be reviewed in this section within the framework of cost-benefit analysis.

3.3.1 The choice of a discount rate

The total effect of flood damages is often distributed over a number of years. It is therefore necessary to look at some procedure for discounting future damages.

Damages are enumerated in terms of a reduction in income *plus* an increase in cost in terms of replacement and repairs. The total effect of a flood from year 1 up to year m (when the effect terminates) can be expressed as follows:

$$S = \sum_{i=1}^{n} \sum_{j=1}^{m} \frac{I_{ij} + K_{ij}}{(1+r)^j}$$

where

S = present value of flood damage in rand

n = number of individuals

m = number of years

I_{ij} = loss in income of individual i in year j

K_{ij} = additional cost to individual i in year j

r = discount rate

The role of the discount rate in the above equation is clear; i.e. the higher the discount rate the smaller the present value of total damages and *vice versa.* Choosing a "correct" discount rate is therefore important for a correct assessment of the long term effects of floods. The principles underlying the estimation of a social time preference rate are of special relevance here.

The social time preference rate is defined as that number, in the form of an interest rate, which expresses society's relative evaluation of future and current benefits, given that there exists a restricted potential in society to transfer the supply of goods and services from one period to the other. The concept of a time preference rate is, therefore, rather abstract but it can supply a framework to guide the planner in his search for a "practical" discount rate. A practical rule is to search for relatively risk-free investments, for example government bonds (James and Lee, 1971). Interest rates on these bonds could be used as a point of departure in presentations to the government. By making the necessary adaptations to this rate the government can then decide on an acceptable discount rate.

3.3.2 Government objectives and damage assessment

Government objectives in the case of national projects focus mainly on efficiency in resource use, growth and redistribution of national income. These objectives serve as a final norm in the assessment of benefits and costs. Although it is preferable to use a single norm as a criterion, various considerations exist in practice which must all be taken into account. The function of cost-benefit analysis is to evaluate as many of these considerations as possible, to express them in the form of a single acceptable criterion, and to present the results in a format which will promote effective decision-making in government. The general practice in cost-benefit analysis is to use money values for tangible costs and benefits and to describe the residual impacts as precisely as possible, without expressing them in monetary terms. These residual impacts *inter alia* include intangible results and the redistribution of income.

To illustrate the importance of the intangible and redistribution implication of floods, a short discussion is presented with the aid of the following social welfare function (James and Lee, 1971):

Maximise $U = f(Y, D, R, O, S, G)$, subjected to resource restrictions.

Where U = social welfare

Y = national income

D = income distribution

R = regional development

O = environmental quality

S = security, stability and safety

G = public health

The parameters of the above function are today generally accepted as objectives for planning in Western democracies. Of them only national income is measured directly in monetary terms while the units of measurement for the others are unique and distinctive to each parameter. Some aspects associated with the policy parameters are now discussed.

Income redistribution

Some of the potential impacts of a flood on income redistribution are briefly discussed in order to illustrate certain implications for flood damage assessment.

- Processing industries such as wine-cellars and vegetable and fruit processing enterprises may have a shortage of inputs to process as a result of the flood. Consequently profits as well as salaries paid out to employees may decline with further chain reactions in the regional economy.

- Income redistribution may occur within the same type of enterprise. A bridge may, for instance, be washed away causing the loss of business to a hotel, which is transferred as a gain to another one. Also, repair work to flood damages may benefit some enterprises more than others.

- The buying pattern of flood victims may change as a result of the flood. They may, for example, be inclined to buy less of certain items that are normally purchased (for example motor cars) and more of others (for example agricultural implements and building materials). An income redistribution may thus result.

Regional impact of flood

Perceptions of flood damage in a region or town may differ according to the scope of the investigation, i.e. whether it is local, regional or national. For example, if government aid is supplied to a region, the real damages will decrease from a regional viewpoint, while from a national viewpoint it is only transferred to the national economy as a whole. Loss in business caused by the flood in one region which is made up in another region, is a damage to the first region from a regional viewpoint, but not necessarily from a national viewpoint. Moreover, the effect of a flood on a town or region may be of a temporary or permanent nature and may manifest itself in different forms. For example, the damage to property in a region may decrease the income base of an individual who suffers damage as well as the tax base of the local, provincial and central authorities. Business may be transferred (temporarily or permanently) from one region to another, causing individuals to leave the former region to settle elsewhere.

Environmental quality

Environmental quality refers to the potential of man's natural and developed environment such as tree, veld,[1] islands, cultivated lands, gardens and buildings to supply the tangible and intangible amenities of life. The negative effect of floods on environmental quality is usually most noticeable immediately after a flood when devastation is at its worst. However, in the process of reconstruction the quality again improves and after completion it may in some respects be even better than before.

Security, stability and safety

Uncertainty with regard to the economic welfare and safety of individuals in a flood plain may lead to various forms of preventative action. On the one hand, it may be uncertainties associated with the possibility and inconvenience to leave a house during a flood or also to travel detours because of the floods. On the other hand, it may be related to anxiety. An analysis of the different preventative actions by individuals may in this case be a point of departure to evaluate the implications of a higher degree of security to a community.

Public health

Different examples may be cited of the potential detrimental effect of floods on public health.

- Individuals in need of immediate medical care may be hampered in receiving this care, because bridges are washed away or roads are untraversable. roads.

- Drinking water may be polluted, leading to a possibility of gastro enteritis and costs associated with inoculation campaigns.

- Certain diseases, for instance malaria, may be exacerbated.

- People may die or drown as a result of the flood.

The impact of floods on health can be measured on the one hand, by assessing the costs accruing from prevention, and on the other hand, specific cases such as deaths and diseases may be specified separately.

3.4 INDUCTIVE AND DEDUCTIVE PROCEDURES

In flood damage assessment both inductive and deductive research processes are relevant.

A prerequisite for the successful application of the deductive process is the availability of adequate and accurate data, such as depth of inundation, drag force of the flood, sediment content and land utilisation pattern, as well as applicable loss functions. This information may be incorporated in simulation models for planning purposes in order to assess flood damage in an *ex ante* context. However, this process may also be applied in an *ex post* sense, serving, as a short cut method for determining flood damage in the event of a flood. In the absence of adequate information regarding certain parameters, one is forced to resort to inductive research procedures. Here the researcher is limited to an *ex post* assessment.

A third situation is where the two processes may be applied simultaneously in flood damage assessment. This implies that information and models are available for forecasting purposes which can then be supplemented by inductive procedures in order to obtain the complete picture.

3.5 EVALUATION OF DIFFERENT FDA PROCEDURES

A review of flood damage assessment practices revealed that methods based on reported damages have a worldwide application. It is conspicuous that these techniques are applied during the initial phase of flood damage research. However, researchers tend to work towards various short-cut methods and situation-simulation techniques.[2] This is a logical course of events because comprehensive surveys after a flood supply basic information which might be successively applied to later floods, thus forming a basis for other investigations.

1 That is natural pastures.

2 Situation-simulation techniques are techniques which define the circumstances surrounding a specific flood and the associated damages in a structural and causal manner.

3.5.1 Reported damages

Flood damages may be assessed from comprehensive surveys, sampling surveys and indicator methods. Both comprehensive and sampling surveys are dependent on methods using standard questionnaires. Usually interested parties are included in the surveys with specifically constructed questionnaires to cover different categories of activities in the flood plains. If the sample universe is unknown, it is preferable to undertake a comprehensive survey. Sampling pre-supposes some foreknowledge of the relative importance and presence of the critical parameters on which the sample is based. The greater the heterogeneity of these parameters in the flood plain, the larger the size of the sample will have to be in order to ensure statistical representativeness.

The advantage of representative surveys lies in the fact that damage assessment can be handled from different viewpoints by simply adapting the questionnaires and choosing the respondents correctly. Although this method has the potential of supplying accurate data, there are a number of practical problems causing the final results to be less accurate. Of these, the human factor is one of the most important e.g. the timing of the survey may markedly affect the reactions of respondents on flood damage (Dacy and Kunreuther, 1969, p. 9). Thus it is most likely that the impressions of both enumerator and respondents may cause an over-evaluation of flood damage immediately after a flood. On the other hand, when surveys are conducted immediately after a flood, certain retarded long term effects, such as the peeling off of wall paint or cracking of walls, may be excluded from the assessment (Nissen, 1968, p. 28). In general, surveys of flood damage by personal interview are prone to all the known shortcomings of this method. Because of these problems, and also due to the time-consuming and expensive nature of comprehensive surveys, it is understandable that these surveys are normally only undertaken as a first step to supply an information base for FDA.

Indicator methods refer to those methods where a specific observation is regarded as being representative of a complex of observations, for example when sales value, occupational pattern, insurance payments and other indices are utilised to assess flood damage. Remote sensing is one indicator method which has already been applied in surveys of water resources and flood plains (Kellerhals, *et al,* 1967; Parker, *et al,* 1970). Another indicator method that has been applied in a number of economic studies is the use of land values in determining flood control benefits (Boxley, *et al,* 1969; Struyk, 1970). However, in most cases where this method was tested against conventional methods, it supplied unreliable results particularly where the flood plains were narrow and the soil types of inundated and uninundated land differed. With a certain amount of success, Weisz and Day (1974) applied this method in urban areas.

3.5.2 Simulation techniques

Situation-simulation methods differ from those based on the analysis of reported damage in the sense that the main objective here is to project and not to describe. Models are used for purposes of estimating potential damages within a planning framework. Because projection is the main objective, heavy reliance is placed on pre-determined functional relationships between flood damage and one or more flood parameters of which depth of inundation is the most common (White, 1964).

CHAPTER 4

PROCEDURES FOR MEASURING FLOOD DAMAGE

Because of the lack of flood planning indicators in South Africa it is clear that short-cut methods cannot be applied effectively in this country at present. The rest of this discussion will focus on the identification of flood damage information and the associated research procedures to be followed in order to obtain the necessary data for descriptive purposes.

4.1 PRIMARY DAMAGES

The flood damage pattern is normally overshadowed by primary damages. This category will therefore receive most attention in the subsequent discussion on FDA. Primary damages can be subdivided into direct and indirect losses as follows:

Examples of direct losses are losses to:

- Municipal property and public lands;
- residential and other buildings in urban areas;
- moveable equipment in buildings in urban areas;
- property of other public authorities in and outside municipal areas (for instance roads, bridges, railroads, telephone and power lines);
- agricultural land;
- crops and harvests;
- livestock and other animals;
- fixed improvements and other equipment on farms;
- stock in and outside farm buildings.

Examples of indirect losses are losses:

- in productive manpower;
- on returns from resources, such as agricultural land which lies unutilised for certain periods;
- due to delays in transportation and other services.

Guidelines for the handling of these damage categories will now briefly be elaborated on.

4.1.1 Prices

The first consideration in measuring damages concerns the prices to be used. Problems in this respect have already been discussed in the previous chapter.

4.1.2 Damage to public services

During the research on South African floods it was accepted that measures taken by public authorities reflect the preferences of these authorities and by implication, also the preferences of the community. Accordingly, prices should reflect bargaining within the free market price system subject to the specifications of a social welfare preference ordering. It was not the objective with this research to evaluate any new public services, and the assumption was therefore made that the existing services represent the social preferences of the respective communities. Repair expenses to flood damages plus the running cost of these public amenities (all at market prices) during the period when the services were not in general use, were also included in the calculations of losses.

The methodology according to which the running expenses should be included as a social loss is based on the premise that a community will continue to spend on public services up to a point where marginal social benefits equal marginal social cost. This rests on another assumption, namely that there is no surplus capacity in the economy. If it can be accepted that the supply of public services is subject to a decreasing social marginal utility, thus leading to a negative sloping demand function, then the social loss is underestimated in this instance by an amount equal to the community surplus, during the consumption of public amenities.[1] This is the case when alternative amenities are not available and when the repair cost of flood damage *plus* running cost, during the period in which these amenities were not in general use, have already been accounted for. This under-estimation is denoted as area A in Figure 4.1, and the running cost of supplying the amenities as area B. In the event of alternatives being available (for instance sporting facilities) the social cost of the flood, apart from the repair cost, will be equal to area B (running cost) *plus* the additional expenses to aquire the services.

More often than not (in contrast to the case of general consumer goods) no alternatives for public services exist. This implies certain intangible losses (generally denoted in the community surplus) which

1 Community surplus is the aggregate of all consumer surpluses in a community.

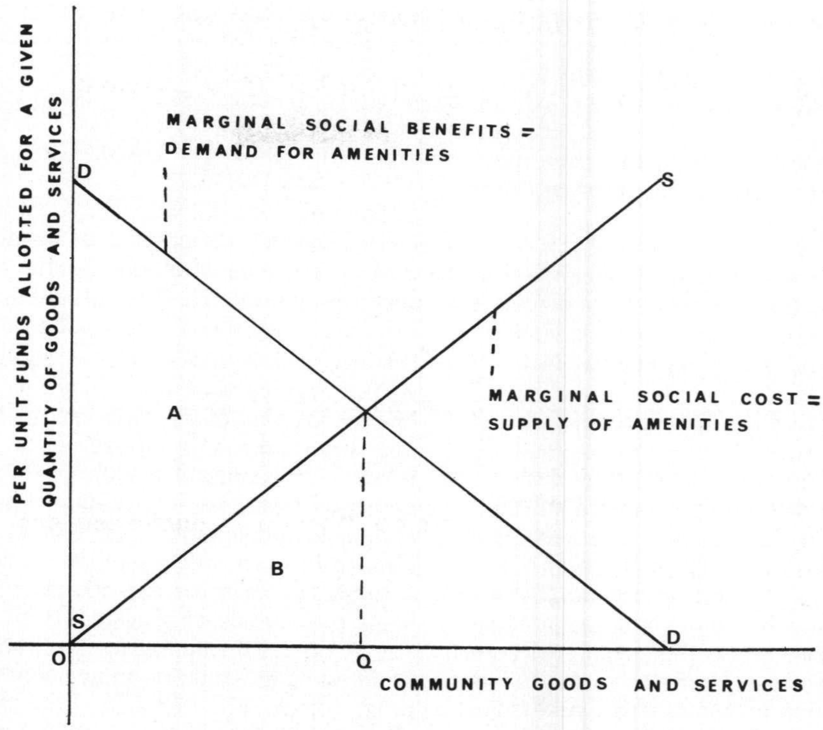

Figure 4.1: Supply and demand of community goods and services, with community cost B and community surplus A at a supply of a given quantity OQ of goods and services.

cannot be quantified, meaning that the calculated figure gives an underestimation of the losses.

4.1.3 Choice of a discount rate and the handling of inflation

As already discussed, if the central government gives no indication of which discount rate to apply, the most suitable seems to be the interest rate on long term government bonds.

Another problem with respect to long term effects, centres on inflation, i.e. a frontal increase in all prices. Due to the fact that considerations regarding a suitable price in the assessment of flood damages is associated with a relative norm, namely opportunity cost, a general rise in price levels may be ignored. Existing prices (i.e. during the flood) can therefore be used in long term assessments. This approach ignores possible long term structural change in the economy which may affect relative prices.

4.1.4 Damage to buildings and contents

Repair and replacement cost forms the basis for the calculation of damage to buildings and their contents. Any improvement on the pre-flood situation of buildings, equipment and stocks should be excluded from the assessment. This approach also applies to other structures and services such as roadways, railroads and bridges. In the case of industries, business and public institutions (given full capacity in the economy) the running cost, for example wages and salaries, incurred during the time of interruption, must be included as a loss.[1] Caution should be exercised against double assessment. The use of employees of affected institutions for purposes of flood damage repairs and disaster aid should not again be entered as a cost in flood damage estimation. In cases where sources of supply to consumers are totally cut off, sales losses should be included as flood damage. The latter situation will occur only in exceptional cases, for instance during a power interruption, where a single institution usually renders the service. Where alternative suppliers of goods and services are present, a disruption in the normal supply pattern represents a transfer between groups in the economy and no social cost is involved.

4.1.5 Damage to agricultural land and crops

Damage to agricultural land is calculated by adding the restoration expenses to the nett loss in productivity. As alternative, the market value of the agricultural land concerned may be used if this market value is lower than the restoration cost *plus* nett loss in productivity over time. Losses to crops are calculated by taking the market value of a crop *minus* all the expenses that would have been necessary to market the crop. Thus, for instance, all running expenses necessary in crop production, excluding the cost of planting, would be deducted from the expected market value if the crop was

1 In the event of alternative supply sources not being available to clients, this procedure will underestimate the damage. Normally it is assumed that alternative supply sources do exist.

washed away just after planting. In the event of the crop having been washed away just after reaping, flood damage is the value of the crop *minus* marketing and transportation costs.

4.1.6 Damage to livestock, fixed improvements, stock equipment and contents of buildings on farms

Damage to fixed improvements, stock, equipment and contents of buildings on farms should be handled as explained in paragraph 4.1.4. Livestock losses are taken at the acceptable market price *less* marketing cost.

4.1.7 Loss of productive manpower

Loss of productive manpower (excluding deaths) is taken as a component of running expenses during the period of interruption. If, for instance, a factory has to close down for a certain period on account of a flood, the running expenses, including labour cost, are included as flood damage.[1] Where the flood prevents persons from getting to their work, the social cost equals the wages and salaries of these persons during the time of absence. An exception in this case is where adjustments are made in leave arrangements or work locations are changed.

4.1.8 Losses due to delays and detours

Losses due to delays are often intangible. Unless a delay has an explicit impact, such as losing an export contract, most evaluations could include highly subjective components. In some cases delays can also be partially overcome by short term adjustments in strategies (i.e. reorganising a work program) again leading to the problem of how to evaluate the residual impact of the delays. It is therefore necessary to exercise great caution when evaluating delays. Preferably a complete description of the situation should be given. The additional expenses, associated with detours, can likewise only be determined satisfactorily if complete origin-destination studies on public roads are conducted. An alternative method in this respect is to take the capital value of the unused road and allocate a cost of say 10 per cent per year of this value for the period the road was in disuse. However, this method is still unsatisfactory as it only partly accommodates the total social cost of flood damage. It is also difficult to determine the part of the road which is in disuse, as well as the percentage decrease in traffic in other parts carrying less traffic on account of the interruption. In cases where the cost accruing from delays and detours can be determined from individuals, quantification is relatively simple. Standard vehicle cost and salary information may be utilised to calculate the cost per kilometre or per hour.

4.2 SECONDARY DAMAGES

Secondary flood damages originate from linkage effects in an economy. Suppose, for instance, that a factory which produces strategic inputs for other factories becomes inundated. The production process at the factories using these inputs will therefore be affected. Disturbances in the supply of goods and services, as well as in price structures, may then result. Secondary effects become more important as the relative economic importance of a flooded region increases and *vice versa*. A meaningful evaluation of secondary effects demands extensive information regarding the forward and backward linkages. This type of information can be obtained from regional or national input-output analysis, or from macro-economic models which evaluate interactions on a system basis.

A practical solution for the handling of secondary flood damage would be to evaluate it up to the second order effect. For instance, only the damage of co-operatives receiving fewer agricultural products will be taken into consideration. Further linkage effects, if any, are not considered. This procedure is generally applied in the United States of America (Harrison, 1976). The supporting argument for this procedure is firstly, that the majority of projects are relatively small when weighed up against the national economy, and secondly, that surpluses of most of the raw materials may exist in the short term. These surpluses are found in the form of stocks of raw materials and goods that are stored by individuals and institutions. In such cases the use of linkage effects would over-evaluate the impact of flood damages.

4.3 INTANGIBLE FLOOD DAMAGES

As already discussed, intangible flood damages include damages such as re-allocation of incomes, changes in the environmental quality, sickness and death. A number of examples exist according to which researchers attempted to quantify intangibles in terms of money (Sinden, 1967; Mishan, 1971). However, these approaches would merely be experimental flights if they were tackled without guidelines from the public authorities concerned. The most appropriate procedure would be to describe the intangibles, or where possible, to indicate the relationship between the intangibles and other activities.

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1 In the case where staff is occupied for purposes of emergency aid or other flood services, caution must be exercised against double assessment.

CHAPTER 5

PRACTICAL APPLICATION AND PROBLEMS OF PROCEDURES FOR FLOOD DAMAGE ASSESSMENT

In this chapter specific procedures for flood damage assessment within an *ex post* context will be described. Where relevant, potential problems to be encountered will be highlighted. Although the surveys in the flood plains form the most important component (in terms of time and volume) of the research, a certain amount of preliminary work has to be done first and this part of the research should not be regarded as of lesser importance.

5.1 INVESTIGATION OF CENTRAL DATA SOURCES

An investigation of central data sources has three objectives. Firstly, to identify different individuals, undertakings, and public and other institutions that suffered losses or were indirectly concerned with flood damage. Secondly, to tentatively determine the type and scope of the damage as well as the involvement of different individuals and institutions. Thirdly, to obtain any additional data necessary for the investigation, the so-called secondary data, e.g., prices of products and inputs; data on production cost; descriptions of production practices, especially on farms; maps of the floor plain; and certain hydrological data such as the location of the flood line and depth of inundation at different points.

5.1.1 Investigation at institutions

Relevant institutions include government departments, provincial and municipal authorities and other institutions such as welfare organisations and insurance and other companies. Personal interviews at these institutions are imperative at the initial stages of the research in order to identify their activities during and after the flood as well as the scope and type of information available. The information to be obtained from these institutions can be divided into four categories, namely the occupational pattern in the flood plains, the physiographical characteristics of the flood plains, the type and magnitude of flood damage for specific river reaches, and other supplementary information.

5.1.2 Identification of individual flood victims

The location and type of human activities (occupational pattern) in the flood plains must also be identified because the sample universe is usually unknown. To achieve this, aerial photos of the flood plain are valuable instruments although more often than not these are not available. Furthermore, visits should be made to local authorities, magistrates extension officers, co-operatives and agricultural leaders. In addition to this and in order to identify owners of fixed property, topocadastral and compilation maps can be used together with information gathered from the Deeds Office. In towns and cities this information may be supplemented by maps of the municipal area where the flood line can be drawn in by functionaries of the municipalities.

In the South African case the necessary hydrological data are inadequate and it is therefore important to at least make an attempt to determine the depth of inundation as well as the duration of the flood. For the purpose of flood damage research contour intervals indicated on the maps available in South Africa are usually too wide. Until such time as this limitation is rectified, the researcher must rely on physical marks (for instance, flood marks on walls) and on the personal, and often highly subjective opinion of the respondents.

5.1.3 Obtaining secondary data

One of the main objectives about collecting secondary data is to compile accepted standards for purposes of calculating flood damage.

The prices of products and inputs may be obtained from persons and enterprises within the area being investigated, for instance merchants and co-operatives dealing with these specific products. Prices and price indices of products and inputs are also available from various government publications. Evaluations of buildings and land in municipal areas can be obtained from the municipal authorities, while estate agents can supply information regarding the market values of farm land and also properties in towns and cities.

The Ministry of Agriculture disposes of an extensive amount of information with respect to production costs on a regional basis. In some cases it would be advisable to verify these figures by way of group discussions with extension officers and farmers. Likewise, information about the production pattern and production practices may be obtained and afterwards verified by on-site visits to farmers and other parties concerned.

5.2 ON-SITE SURVEYS IN THE FLOOD PLAINS

5.2.1 Coverage of area to be investigated

After the preliminary investigations have been completed and, among other things, the flood victims have been identified, the first consideration is whether the compilation of data should be done by sampling or by coverage of the whole area. In most cases practical considerations such as available time, manpower and funds will be the decisive factors. The degree of accuracy required by and objectives of the principal will also have to be considered. In the event of the assessment being done for the first time, it can be expected that a reasonable degree of accuracy will be required, in which case a coverage as complete as possible is desirable.

In practice, however, different factors play a role. The most important of these are the following:

- Some flood victims may have departed after the flood. Often they cannot be traced or in cases where they can be traced their new residence is so distant that a visit is unpractical.
- By the time of survey some of the people affected by the flood may have passed away.
- In some cases flood victims are simply unable to supply the correct information.
- Sometimes the area is so large and the potential respondents so numerous (for instance intensive irrigation schemes in flood plains) that a sample survey seems the only option.

In the event of complete coverage missing information may be obtained from neighbours, especially to determine whether specific deviations from the normal damage pattern were present. In the case of urban areas where damage is unknown, an attempt should be made to obtain the floor space and depth of inundation and then estimate the damage by using the data of similar dwellings with the same depth of inundation.

A certain amount of variability often exists within and between river reaches and this will influence the size of the sample. It is, therefore, advisable especially in the case of agriculture, to stratify the reaches into smaller homogeneous units according to topographical, climatological and land use pattern before drawing the sample. Finally, after the average damage per respondent has been determined, this figure is multiplied by the total number of flood victims in order to arrive at a total damage figure. The average damage per area unit for typical land use patterns may serve as a useful basis in calculations.

5.2.2 Survey procedures and processing of data

Prototypes of questionnaires which were used in FDA in South Africa are included in the Appendix. Before the actual surveys, questionnaires should be thoroughly tested and adjustments made where necessary. During the survey all questionnaires are completed by personal interview. Apart from the fact that respondents are unable to complete these by themselves, experience has proved that the mailing in of questionnaires evokes little reaction.

5.2.3 The classification of damage categories for data processing

Classification of damage in urban areas

Apart from the basic classification of flood damage into direct and indirect primary tangible damages and intangible damages, a functional land use classification should be made in urban areas. In each town or city the damage should be divided according to item between direct, indirect and intangible for each of the functional land uses, namely residential, commercial, industrial, public services, educational, denominational and private sports grounds.

Classification of the damage to institutions

The damage and/or involvement associated with institutions should as far as possible be analysed by river reach, according to direct damage, indirect damage, intangible damage and involvement. Involvement includes the transfer payments made by public and other institutions to individuals and institutions. This *inter alia* refers to *ex gratia* payments, subsidies, donations, insurance payments and funds for expropriation. The latter is included to complete the flood picture, but is not included as flood damage.

Classification of the damage to farms

The damage to farms is analysed downstream for each reach and, where applicable, sub-divided for each item into direct, indirect and intangible damage.

5.3 DESCRIPTION OF DAMAGE CATEGORIES

In this section some possible damage categories will be discussed. It should be noted that some of these damage categories could appear in both farming, industry and urban areas as well as the public sector.

5.3.1 Damage to land

All tangible damage, irrespective of the purpose for which the land is used, is included as direct damage. Direct damage includes damage to restorable and irrestorable land. Where land is restorable, the real estimated cost to restore it to the pre-flood condition is taken as damage. The removal of debris from the land and the repairs to trellises of vineyards, are also included in this category. In the case of restorable natural grazing which could recover by itself in the course of time, no cost should be allotted. When land is declared as irrestorable, the market value is entered as a direct damage. The value of perennial crops on such land has, by implication, been included in the market value and is therefore excluded from crop damages, except in the case of a harvest that was lost during a flood. For a correct evaluation from a national point of view, *ex gratia* payments made to farmers who owned irrestorably damaged land are not considered as a measure of damage, but the full market value of the land is used in this instance.

5.3.2 Damage to crops and harvests

It is possible to differentiate between direct and indirect crop losses. Damages to crops and harvests are classified as direct damages. Damage to harvests denotes the losses due to a specific flood in the year of investigation. That part of the harvest losses that could have been avoided if excessive rain did not fall (rain damage) is not considered as flood damage. However, indirect damage may also result if the crop was not inundated, but on account of extremely wet flood-related conditions, it could not be reaped. Direct harvest losses may be described as follows: When harvests of annual and perennial crops are partially or totally damaged, the loss in income due to the flood, *minus* the saving in harvesting cost (a certain portion or the whole crop was not harvested) is taken as damage.

Apart from the damage to harvests, damage to crops can also occur in the case of perennial crops, e.g. losses due to the inundation of vineyards, orchards and grazing land. This damage is normally spread over a period. In determining these damages, the prices of the base year are used and an appropriate discount rate, as discussed, applied.

With regard to perennial crops different situations may arise, requiring different methods of evaluation:

- If the crop recovered or was replanted, the damage is the discounted value of the total additional expenses due to the flood (at base year prices) *plus* the total loss in income due to the flood (also at base year prices), for as long as it deviates from the normal production pattern.[1]

- In the event of continuing production with a damaged crop that would recover after a period, flood damage is the discounted value of the decrease in income *minus* the savings in harvesting cost (due to a smaller crop) for the period of lower crop production. In the event of non-recovery the same method of calculation is followed, but the period is set on the number of years it would take for a new crop to come into full production.

- If the damaged perennial crop is replaced with another one, flood damage is the discounted value of the loss in nett farm income[2] over the number of years it would take the new crop to come into full production.

- Another example of crop damage is where the damaged crop is neither replaced nor replanted and agricultural land is left idle. Flood damage would then be the discounted value of the loss in income for the number of years it would take a new crop to come into production *minus* the cost to produce that crop.

- If the land where a crop was established before the flood is irrestorably damaged, the crop damage is incorporated in the land value.

Damage to natural grazing is measured in accordance with the implications it has on the income and cost structure of a livestock farm. If the farmer is compelled to decrease the number of livestock on account of damage to grazing land, the losses can be estimated on the basis of nett farm income per livestock unit.[3] The calculation is done as follows:

$$S = \sum_{i=1}^{j} (N_i V_i + A_i),$$

Where S = flood damage;

N_i = discounted value of nett farm income per livestock unit in year i;

V_i = number of livestock units withdrawn in year i;

j = number of years of withdrawal; and

A_i = discounted value of feedstuff bought in year i.

The inclusion of the cost of feedstuff may give rise to double counting if cultivated fodder crops are also damaged. The incorporation of feedstuff costs in the case of grazing land losses must therefore be connected only to grazing land losses and not to replenishment due to losses in cultivated fodder crops. In practice, excessive rainfall during the period in which a flood occurred might prove beneficial to grazing land. In this case farmers may be able to move their livestock to other camps without having to decrease the number of livestock, in which case damage to grazing land is not applicable in the calculations.

Where shrubs and plants in gardens are damaged, a standard value is attached to a shrub (or plant) and the cost of re-establishment added. Such losses also embrace intangibles and this procedure will therefore be on the conservative side.

The following indirect damage to crops should also be included when assessing flood damage:

- Increased expenses due to the floods in combating weeds:

$$S = \sum_{i=1}^{j} (B_{vi} - B_i),$$

Where S = flood damage;

B_{vi} = discounted value of weed combating after the flood in year i;

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1 Because the life-span of a perennial crop cannot be precisely determined, it can be assumed that the re-establishment of such a crop does not necessarily increase its life-span. In this respect it is therefore not necessary to make adjustments to the damage estimates.

2 Nett farm income = Total income *minus* running costs, *minus* fixed costs. Interest on capital investments is not considered in the calculation of nett farm income.

3 One livestock unit = 1 large cattle unit, 2 cattle units 1-2 years old, 3 calves, 6 sheep, 6 goats and 9 weaned lambs.

B_i = discounted cost of weed combating in the absence of a flood in year i; and

j = number of years of increased cost.

- Delays in the planting of crops due to a flood can give rise to losses which can be calculated as follows:

$$S = \sum_{i=1}^{j} (N_i - V_{vi}),$$

Where S = flood damage;

N_i = discounted nett farm income in the absence of a flood in year i;

N_{vi} = discounted nett farm income after a flood in year i; and

j = number of years the delays occurred.

- Where crops cannot be irrigated on time, the flood damage is the total discounted value of yearly losses in nett farm income for the period this situation lasted.

in the process of assessing damage, all possible gains due to the flood, such as additional crops harvested, must also be identified. These gains are then subtracted from the calculated flood damage.

5.3.3 Damage to buildings

Damage to buildings can be tangible (direct or indirect) as well as intangible. Direct damage occurs when a building in inundated and damage is caused on account of physical contact with flood water. Indirect damage may occur when a building is not flooded but for instance, walls may crack where the flood water disturbed the physical characteristics of the foundation of the building. Damage to historical buildings on the other hand has an intangible content.

When a building is restorable, the repair expenses (or an estimate thereof) to pre-flood conditions is taken as flood damage. In the case of both restorable and irrestorable buildings the cleaning up expenses are also added to repair and replacement cost. In the event of the floor space being enlarged the repair or replacement cost is *pro rata* reduced to include only the original floor area. Where buildings without functional value are washed away, no damage is included in the calculations.

In the case of functional buildings being irrestorably damaged, the market value (if available) is taken as flood damage. Where the market value cannot be obtained, as is usually the case with farm buildings, the replacement value is taken after subtraction of future savings in normal repair cost (6 per cent of replacement value) as well as the scrap value of the remaining material. When calculating the losses of irrestorably damaged buildings, it is assumed that one round of repair work falls away. In other words, the fact that the building is replaced, implies a saving in repairs which equals approximately six per cent of the replacement cost. The underlying assumption is that during the flood, repair work was required but not undertaken on account of the fact that the building was being replaced. Intangible damage is merely described.

5.3.4 Damage to other fixed improvements

Other fixed improvements which would possibly be damaged by floods are the following:

Soil conservation works

Check walls (earthern embankment)
Contours
Stone walls
Weirs

Livestock watering works

Reservoirs
Windmills
Powerheads
Boreholes
Dams
Pipelines
Troughs

Private irrigation works

Irrigation dams
Diversion walls
Channels and irrigation furrows
Drainage systems
Emergency embankments

Diverse fixed improvements

Dips
Kraals (Folds)
Silos
Fences
Roads and bridges

Although it is theoretically possible to distinguish between tangible (direct and indirect) as well as intangible losses in the case of damage to fixed improvements, it might be adviseable to refer only to direct tangible losses.[1]

Basically, the same calculations are done as in the case of buildings. Direct damage should be included only if the damaged item was still functional before the flood. If the fixed improvement is restoreable, flood damage is calculated on the basis of the repair cost to restore it to

1 An example of indirect damage may be where a channel cracks (although it was not inundated) due to the caving in of the soil. Another example could be where the water of a borehole becomes brackish on account of the flood. Intangible damage may for instance occur when trees on the river banks are washed away and where an intangible value (environmental quality) was attached to these.

pre-flood conditions. When a fixed improvement cannot be restored to pre-flood conditions, flood damage is taken at the market value of the item and when this in unknown the replacement value is taken.

When the damaged items have not been repaired or replaced and the respondent is unable to estimate the damage, standard values should be used. These values are obtainable from institutions such as government departments with first-hand knowledge of this type of repair work. Standard values may also be used as a check on the respondent's damage estimate.

5.3.5 Damage to contents of dwellings

The following items are generally found to be damaged by floods in residences:

Kitchen equipment

Refrigerators
Deep freezers
Stoves
Kitchen tables
Kitchen chairs
Kitchen dressers
Crockery
Cutlery
Groceries

Bedroom equipment

Carpets
Wardrobes
Dressing tables
Beds
Mattresses
Blankets
Clothing

Dining room equipment

Carpets
Chairs
Tables
Buffets

Living room equipment

Carpets
Paintings
Chairs
Settees
Tables
Radios
Television sets
Heaters
Display cabinets
Books

Other

Vacuum cleaners
Lawn mowers
Curtains
Writing-desks
Sewing-machines
Scales
Washing machines

In this category it is also possible to distinguish between tangible (direct and indirect) as well as intangible damage. An example of intangible damage may be the sentimental value as well as non-quantifiable antique value attached to furniture. Indirect damage again may occur where, in the process of flood damage prevention, furniture was damaged during removal or perhaps by rain. Direct damage occurs in the case of physical contact with the flood water. Here also, damage is included only if the damaged item was functional before the flood. Where items are restorable, the repair cost or an estimate thereof is taken as tangible damage. When items cannot be restored to pre-flood conditions, the market value is taken as damage and in the absence of a market value, the replacement value.

5.3.6 Damage to stock

The following stock items were generally listed during surveys:

Fertilizer
Concentrates
Lucerne bales and other feedstuff
Fuel
Fuel containers
Seed
Rations
Tools
Hessian bags

The type of damage to stock is usually tangible and direct, although indirect damage may also occur, for example, during the transportation of stock. The market value of stock items is generally available. In the case of damaged farm produce such as lucern, the farm price is used, whereas in the case of purchased goods, the retail price is used.

5.3.7 Damage to vehicles, machinery, implements and equipment

Damage in this category is mainly direct. Indirect damage relating to the travelling of detours was discussed in section 4.1.8.

In the case of repairable damage on items which are still in use, the repair cost or an estimate thereof is taken as damage. In the case where used spare parts have to be replaced by new ones and the cost of the new part is taken as flood damage, an over evaluation is made. However, if labour cost and the value of the spare parts can be obtained separately, the value of the new spare part can be written off at a rate of 15 per cent per annum according to the age of the replaced part. In the case of irrepairable damaged items the same depreciation rate is applied.

5.3.8 Livestock losses

Livestock losses may be direct as well as indirect. In the event of animals being lost on account of physical contact with the flood water, for example drowning, damage is direct. Indirect damage to livestock may occur through a loss in income in the case of productive animals (for instance a drop in milk production) or costs incurred on account of injuries or the outbreak of disease. In the case of direct damage, the approach is to take a reasonable market value, whereas in the case of indirect damage, the actual expenses or losses attached to this damage are taken. Expenses associated with excessive rain in combating disease are excluded from flood damage, the argument being that the disease would have occurred even in the absence of a flood.

5.3.9 Other damage categories on farms

During the course of an investigation of this kind, other information with respect to detours, flood damage prevention, higher telephone expenses, additional subsistence expenses, disconnecting of electricity and intangible damages such as illness and loss of life, should also be compiled. The procedure for assessing these damage categories has already been explored. The actual additional expenses regarding flood damage prevention and subsistence are included as indirect damage. In the case of the disconnection of electricity any related expenses such as repair costs and the value of the decreased consumption of electricity should be included. If the loss in harvest due to a shortage in irrigation water and the value of the electricity that would have been used for pumping water in included, this may lead to double assessment of loss.

The above-mentioned damage categories are of course also applicable when evaluating damage in urban areas.

5.3.10 Other damage categories in urban areas

Certain damage categories in urban areas which have been discussed in a previous chapter may, for the sake of completeness, also be mentioned here. These are loss in income by business enterprises during and after a flood, loss in tax income by municipal authorities and loss in rentals by individuals and other institutions.

From the standpoint of the individual or institution who suffers the loss, the loss in income is a reality if it cannot be covered. From a national point of view, however, these losses are not included as flood damage, the reason being that these are compensated for elsewhere in the economy.

5.3.11 Other damage categories concerning government and other institutions

Included among these are public authorities on the central government and provincial level, insurance companies and emergency aid organisations. The impact of floods on these institutions can be divided into direct and indirect tangible damage, intangible damage and involvement. The cost to repair properties of these institutions to pre-flood conditions is regarded as direct flood damage. This could for instance include damage to the following: buildings (police stations and post offices), provincial and national highways, bridges, dams, railway lines and telephone and electricity lines. Included amongst the group of indirect losses can be additional transportation, labour, material and telephone costs.

More often than not the defence and police forces of a country incur additional costs by rendering emergency aid. Included here are inspection trips by dignitaries and functionaries of government departments. Additional labour costs refer to all overtime payments on account of the flood, as well as the wages and salaries accruing from the appointment of additional personnel. Among other things, intangible damage may stem from the anguish and inconvenience experienced by functionaries of the different institutions during the course of rendering aid and undertaking repair work.

Involvement refers to the type and extent of donations, subsidies and loans, as well as insurance payments made by public and other institutions to flood victims. From a national point of view these payments are regarded as transfer payments and are not included as flood damage. Likewise, income losses suffered by government on account of the fact that farmers, for instance, have to repair flood damage, resulting in a smaller tax payment than would normally be the case, are from a national point of view not regarded as flood damage.

5.3.12 Some general remarks with respect to aid rendered during a flood

A superficial review with respect to aid rendered during a flood could lead to the general conclusion that this aid, as already mentioned, should be regarded as a transfer payment that cancels out between the recipient and donor. A distinction must however be made. Items such as subsidies, loans and insurance payments are transfer payments from a national point of view and are not included as flood damage. On the other hand, in the case where one farmer rendered aid to another during a flood and labour, implements, tractors and vehicles are involved, the expenses attached to these should be added as flood damage. In order to avoid double assessment, only the aid received is entered as flood damage and not the aid rendered.

In the following chapter a brief résumé of the South African experience with respect to loss functions is presented. Although limited by certain shortcomings, some of these models may well serve to estimate flood damage for planning purposes.

CHAPTER 6

LOSS FUNCTIONS

A loss function defines the relationship between flood damage and certain flood characteristics such as depth of inundation, duration, area inundated, silt content and momentum flux of the flood waters for a specific damage category. These relationships could be expressed algebraically, graphically or in tabular form. The main uses of these functions are to ease the determination of future flood damage and to make the planning of flood control measures possible with the aid of formal planning models.

6.1 GUIDELINES FOR FUTURE RESEARCH

One of the aims of the completed research was to investigate the determination of loss functions. The results of the investigations which could serve as guidelines to future endeavours are as follows:

- It was not possible to obtain data on all the relevant physical flood characteristics, for instance on momentum flux and silt content of the flood waters. The only two flood parameters for which reasonably accurate data could be obtained, were area and depth of inundation. Available data on some other parameters, for instance duration of inundation, were not always accurate enough.
- Sufficient data for the determination of formal loss functions were only available for a few river reaches and damage categories. These categories are single storey residences and some other buildings, perennial crops, different vineyard varieties and soils of cultivated lands.
- Because all the physical flood parameters in the models could not be included, it was in most cases not possible to determine a comprehensive model for each damage category. Separate models were therefore constructed for each river reach. The only damage categories for which models with wider application could be determined were single storey houses and some other buildings. Table 6.1 and Figure 6.1 illustrate these models for different single storey buildings of good quality building material.

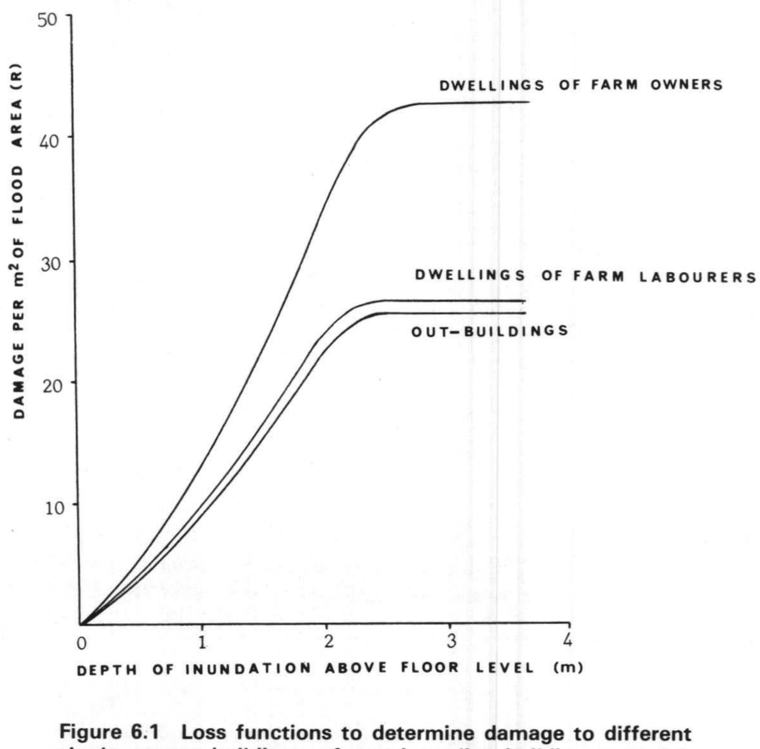

Figure 6.1 Loss functions to determine damage to different single storey buildings of good quality building material, February/March 1974

Table 6.1: Relationships between damage and depth of inundation for different single storey buildings of good quality building material, February/March 1974

Building type	Relationship*	Coefficient of determination (R^2)
Residences of farm owners	$LS = 1,342H - 0,213H^2 - 1,008LH$	0,88
Residences of farm labourers	$LS = 1,120H - 0,222H^2$	0,87
Out-buildings	$LS = 1,158H - 0,235H^2$	0,94

* S = damage in rand per square metre of floor area.

LS = common logarithm of S

H = depth of inundation above floor level in metre (0 to 3,5 m)

LH = common logarithm of H which is equal to zero for $H \leq 1$

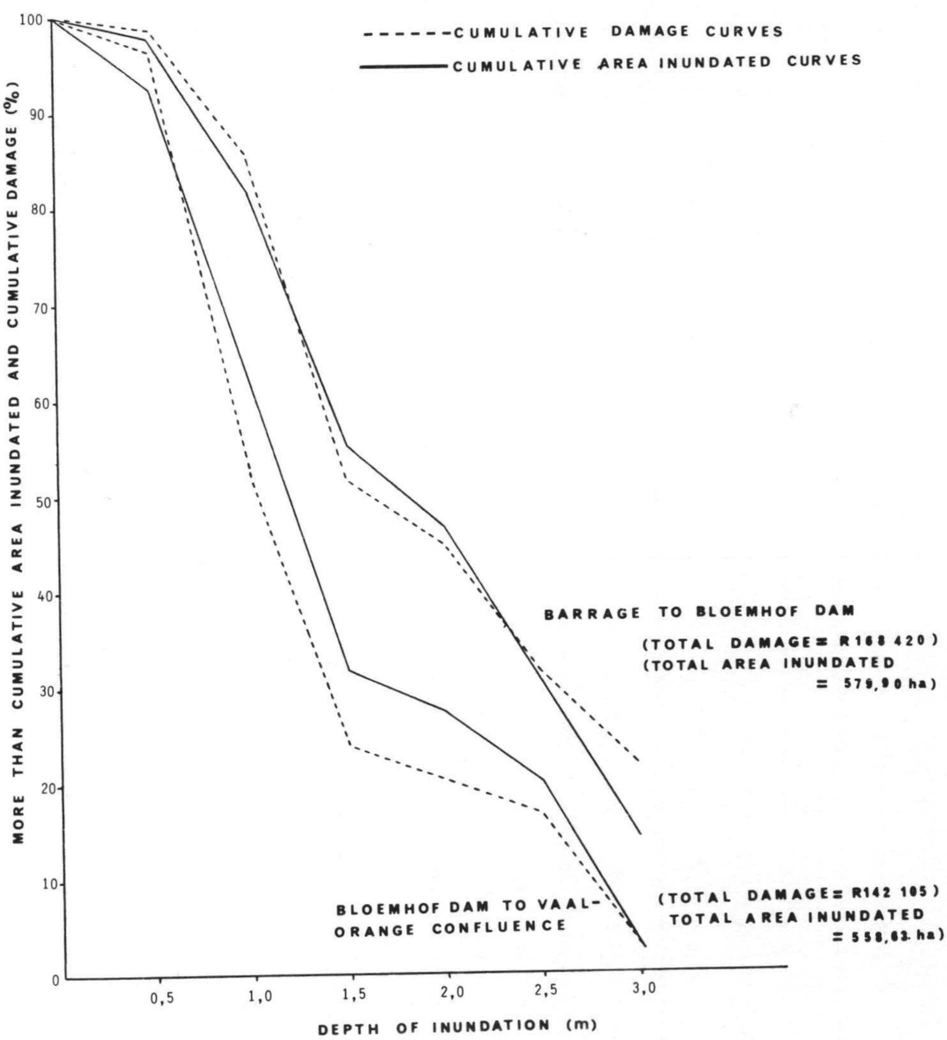

Figure 6.2 More than cumulative area inundated and cumulative damage curves for lucerne and two river reaches of the Vaal River as a result of the flood of February 1975

Table 6.2: The classification, into depths of inundation intervals, of area inundated and damage to maize and lucerne for different reaches of the Vaal River as a result of the flood of February 1975

	Crops and depth of inundation interval (m)													
	Maize							Lucerne						
	0-0,5	0,5-1,0	1,0-1,5	1,5-2,0	2,0-2,5	2,5-3,0	3,0+	0-0,5	0,5-1,0	1,0-1,5	1,5-2,0	2,0-2,5	2,5-3,0	3,0+
				*							*			
Barrage to Bloemhof Dam														
Area inundated (ha)	49,50	305,00	208,03	74,25	115,22	91,11	223,71	11,71	94,93	151,18	48,25	99,16	90,35	84,32
Percentage	4,64	28,59	19,50	6,96	10,80	8,54	20,97	2,02	16,37	26,07	8,32	17,10	15,58	14,54
Cumulative percentage	100,00	95,36	66,77	47,27	40,31	29,51	20,97	100,00	97,98	81,61	55,54	47,22	30,12	14,54
Direct damage (R)	4 910,00	59 856,00	47 516,00	23 329,00	23 822,00	13 665,00	86 693,00	1 949,00	21 290,00	57 103,00	11 950,00	23 088,00	16 697,00	36 343,00
Percentage	1,89	23,04	18,29	8,98	9,17	5,26	33,37	1,16	12,64	33,90	7,10	13,71	9,91	21,58
Cumulative percentage	100,00	98,11	75,07	56,78	47,80	38,63	33,37	100,00	98,84	86,20	52,30	45,20	31,49	21,58
				*							*			
Bloemhof Dam to Vaal-Orange confluence														
Area inundated (ha)	4,00	59,93	225,98	22,13	18,18	118,69	-	39,94	165,58	173.23	26,03	40,56	95,92	17,37
Percentage	0,89	13,35	50,34	4,93	4,05	26,44	-	7,15	29,64	31,01	4,66	7,26	17,17	3,11
Cumulative percentage	100,00	99,11	85,76	35,42	30,49	26,44	-	100,00	92,85	63,21	32,20	27,54	20,28	3,11
Direct damage (R)	281,00	9 188,00	43 299,00	4 408,00	3 567,00	29 783,00	-	4 991,00	63 205,00	39 625,00	4 994,00	5 459,00	19 550,00	4 281,00
Percentage	0,31	10,15	47,83	4,87	3,94	32,90	-	3,51	44,48	27,89	3,51	3,84	13,76	3,01
Cumulative percentage	100,00	99,69	89,54	41,71	36,84	32,90	-	100,00	96,49	52,01	24,12	20,61	16,77	3,01

* Correlation between area inundated and direct damage is statistically significant at a 1 per cent significance level.

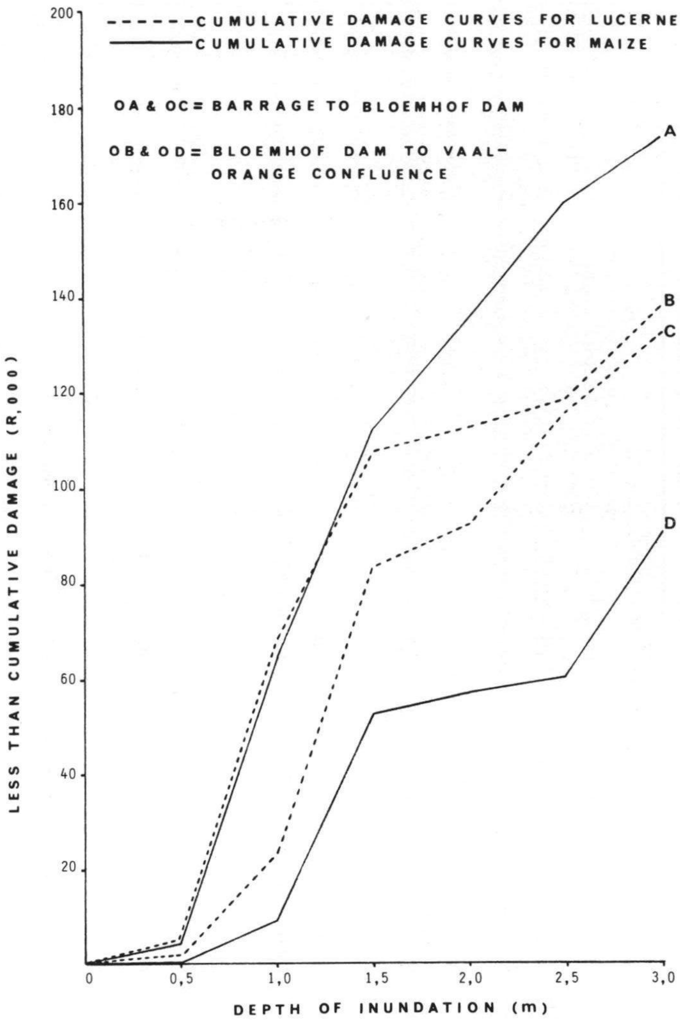

Figure 6.3 Less than cumulative damage curves for lucerne and maize in two river reaches of the Vaal River as a result of the flood of February 1975

- Two physical flood parameters are dominant in the different models, namely area inundated and depth of inundation. For damage to crops it is area of inundation, whilst in the case of damage to building structures and damage to cultivated lands both of these parameters were relevant.

- Given the problems to determine a complete set of formal loss functions the next best solution may be to construct a set of informal loss functions. Informal loss functions refer to the classification of flood damage data for each damage category and river reach. In Table 6.2 and Figures 6.2 and 6.3 an example of such a classification is presented. The damage and the land area (when available) on which the damage occurs are classified, for each damage category into depth of inundation intervals. With this information the damage of future floods (of the same or smaller magnitude) can be determined for a specific river reach, under the necessary assumptions and with minor adaptations. These types of models can be constructed for the largest portion of the tangible damages, namely direct damages.

6.2 APPLICATION OF LOSS FUNCTIONS

Loss functions can normally only be applied to situations where the magnitude of the flood is smaller than the flood on which the loss functions are based. In order to apply formal loss functions, fairly acccurate data on the relevant parameters must be available. For instance, in the case of utilising the functions of Table 6.1 or Figure 6.1 it is necessary to have data available on floor area and depth of inundation for all buildings in a flooded area in order to determine the total damage to these buildings. For each building the damage per square metre floor area is first determined by either using the formulae in Table 6.1 or the graphs in Figure 6.1. Next, the damage per square metre is multiplied by the floor area of the building to obtain the total damage to the building. Completing this procedure for all flooded buildings and then adding up the total damage figures will give the total damage to these buildings in the flooded area. Alternatively the total square metre floor area for coinciding depth of inundation can be added and then multiplied by the appropriate damage figure for each depth to determine the total damage per building category.

Using any type of loss function requires that the necessary assumptions and adaptations should be made. In the case of the example, relevant assumptions will include that the overall flood characteristics (duration, silt content and momentum flux of the flood waters) of the two flood events are more or less similar, that the type and quality of the buildings inundated by the two floods are comparable and that the same degree of flood prevention measures was taken. To allow for future price changes a necessary adaptation will be to increase/decrease the damage by a relevant index, for example the building cost index in the case of damage to buildings.

Use of informal loss functions is restricted to the river reaches on which these functions are based. A typical question that could be answered by these types of functions is: what would the damage be in a certain river reach if the flood happened to be say 1,0 m lower than it actually was? Referring to lucerne (Table 6.2) in the reach Barrage to Bloemhof Dam the damage in the inundation intervals 0-0,5 and 0,5-1,0 m that is R1 949,00 plus R21 290,00 (R23 239,00), would then not have occurred. Alternatively, when using the more than cumulative damage curves in Figure 6.2 one must move along a straight line upwards from a depth of inundation of 1,0 m until the cumulative damage curve for Barrage to Bloemhof Dam is met, then horizontally to the left until the vertical axis is crossed. The percentage reading on the vertical axis will then indicate what percentage of the total damage will still occur. For Barrage to Bloemhof Dam it will be approximately 86,5 per cent or R145 683.

Should less than cumulative damage curves (Figure 6.3) be used instead, one must again move upwards along a straight line from a depth of inundation of 1,0 m until the cumulative damage curve for lucerne and the reach Barrage to Bloemhof Dam is met, then horizontally to the left until the vertical axis is crossed. The reading on the vertical axis will in this case indicate what amount of the total damage will fall away. For Barrage to Bloemhof Dam it will be approximately R23 000. This kind of presentation may also be applied to damage categories where area flooded is irrelevant.

Necessary assumptions for using informal loss functions to assess future damage to crops are that the flood must occur the same time of the year, the crop must be in the same production cycle and that the same land use pattern applies. Adjusting the per hectare damage by the price index for the crop under consideration is a necessary adaptation to cope with the future price changes.

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APPENDIX

EXAMPLES OF QUESTIONNAIRES FOR FLOOD DAMAGE ASSESSMENT

QUESTIONNAIRE FOR THE ASSESSMENT OF FLOOD DAMAGE TO PROPERTIES IN THE FLOOD PLAIN IN TOWNSHIPS

A. Detail of property

Stand No. ______________________________

Area of stand (m^2) ______________________________

Name of enterprise ______________________________

Name and address of owner ______________________________

____

Name and address of tenant ______________________________

____

Name and address of mortagee ______________________________

____

Functional use of building during the flood (e.g. residential, commercial, industrial, etc.)

____

Location: Distance from riverbank (m) ______________________________

Previous occasion the building was flooded (e.g. 22/2/24) ______________________________

B. Detail of damage to buildings

1. Repairable buildings (when irrepairably damaged see p. 63)

Number of stands ______________________________

		Main building	Outbuildings		
Number of repairable buildings					
Date purchased/erected					
Purchase price/construction price ...	(R)				
Floor area (m^2)					
Number of bedrooms (residential)					
Number of storeys					
Type of building material					
Municipal valuation before flood					
Land	(R)				
Improvements	(R)				
Total	(R)				
Divisional Council valuation before flood					
Land	(R)				
Improvements	(R)				
Total	(R)				

	Main building	Outbuildings		
Estimated market value before flood:				
Land .... (R)				
Improvements .... (R)				
Total .... (R)				
Depth of inundation above floor level (m)				
Duration of inundation (hours)				
FOR BUILDINGS THAT HAVE BEEN REPAIRED:				
Number				
Cost of repairs done by yourself:				
Roof .... (R)				
Walls .... (R)				
Floor .... (R)				
Ceiling .... (R)				
Total .... (R)				
Cost of repairs done by contractor:				
Roof .... (R)				
Walls .... (R)				
Floor .... (R)				
Ceiling .... (R)				
Total .... (R)				
Cleaning up expenses .... (R)				
Floor area after reparation (m^2)				
Period of disuse since flood (days)				
FOR BUILDINGS THAT HAVE NOT BEEN REPAIRED:				
Number				

Reason why not repaired ____________________

____

Floor area of sections not repaired (m^2)...				
Estimated costs of repair:				
Roof .... (R)				
Walls .... (R)				
Floor .... (R)				
Ceiling .... (R)				
Total .... (R)				

	Main building	Outbuildings		
Was any compensation received? (YES OR NO)				
IF YES:				
Amount claimed . ... (R)				
.... (R)				
Amount received .... (R)				
.... (R)				
Name of institution				
....				
Were there any after effects (e.g. cracks)? YES OR NO				

IF YES:

Specify ______________________________

____

____

Were the after effects repaired? (YES OR NO)				
IF YES:				
Cost of repairs .... (R)				
IF NO:				
Estimated cost of repairs .... (R)				
Has this amount been included in the previous repair or estimated costs? (YES OR NO)				
IF NO:				
Amount claimed .... (R)				
Amount received .... (R)				
Name of institution				

Remarks: ______________________________

____

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2. Irrepairable buildings

Number of stands ____________________

		Main building	Outbuildings		
Number of irrepairable buildings					
Date purchased/erected					
Purchase price/construction price	(R)				
Floor area (m^2)					
Number of bedrooms (residential)					
Number of storeys					
Type of building material					
Municipal valuation before flood:					
Land	(R)				
Improvements	(R)				
Total	(R)				
Divisional Council valuation before flood:					
Land	(R)				
Improvements	(R)				
Total	(R)				
Estimated market value before flood:					
Land	(R)				
Improvements	(R)				
Total	(R)				
Depth of inundation above floor level (m) .					
Duration of inundation (hours)					
Cleaning up expenses	(R)				
Demolition value (i.e. value of remaining material)	(R)				
Was the building replaced? (YES OR NO) ...					
IF YES:					
Number replaced					
Cost of work done by yourself	(R)				
Cost of work done by contractor	(R)				
Floor area after replacement (m^2)					
IF NO:					
Number not replaced					
Floor area (m^2)					
Estimation of replacement cost to pre-flood condition	(R)				

Will a new dwelling/outbuilding be erected on the existing stand?

YES	NO

IF NO:

Briefly outline the reasons and future plans in this regard ______________________________

____

____

____

IF YES:

What type of building will be erected? ______________________________

When? ____

Will any flood precautionary measures be taken in the event of rebuilding?

YES	NO

IF YES:

What kind of precautionary measures are to be taken? ______________________________

____

____

	Main building	Outbuil-dings		
Was any compensation received? (YES OR NO)				
IF YES:				
Amount claimed .... (R)				
.... (R)				
Amount received .... (R)				
.... (R)				
Name of institution				
....				

Remarks: ____

____

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____

C. Site damages (e.g. cleaning up, trees, shrubs, sewerage systems, swimming pools, tennis courts and fences)

Item	Repair or replacement costs (R)	Percentage improvement above old item	Remarks concerning improvement	Compensation:	
				Amount claimed (R) ...	
				(R) ...	
				Amount received (R) ...	
				(R) ...	
				Name of institution	
				......	
Total					

D. Damage to loose equipment in buildings (e.g. kitchenware, diningroom, bedroom and office equipment)

Item	Year of purchase	Purchase price (R)	Value before the flood (R)	Actual or estimated cost of repairs if repairable (R)	Actual or estimated replacement cost with an identical item if irrepairable (R)	Age of replacement item	Percentage improvement above old item	Remarks about kind of improvements or about items with a sentimental or antique value
X	X	X	Total (R)			X	X	

Compensation:	
Amount claimed (R)	
(R)	
Amount received (R)	
(R)	
Name of institution	

E. Damage to stock (e.g. groceries, deep freeze contents and commercial stock)

Item	Number	Valuation or unit price paid	Selling price per unit	Total valuation:		
					At cost price (R)	
				Compensation:	At selling price (R)	
				Amount claimed	(R)	
					(R)	
				Amount received	(R)	
					(R)	
				Name of institution	....	
					....	

Remarks: ____

F. Damage to vehicles, machinery and other equipment

	Repairable					Irrepairable				
Item										
Number										
Make										
Age										
Capacity										
Value of item before the flood .... (R)										
Estimated or actual repair cost to pre-flood condition .... (R)										
Estimated or actual replacement cost .... (R)										
Age of replacement item										
% improvement above old one										

Was any compensation received? YES | NO

IF YES:

Amount claimed	(R)	
....	(R)	
Amount received	(R)	
....	(R)	
Name of institution		
....		

G. Additional transport cost (e.g. extra trips or detours as a result of the flood)

Type of vehicle					
Capacity of vehicle					
Additional kilometres travelled during and after the flood					
Cost per kilometre ....(c)					
Number of labourers involved:					
Skilled					
Unskilled					
Wages per hour					
Skilled .... (c)					
Unskilled .... (c)					
Total transport cost .... (R)					
Total labour cost .... (R)					

H. Lost in income

Was the enterprise closed on account of the flood? YES | NO

IF YES:

Loss in turnover during the time closed .... (R)

Loss in turnover after re-opening until in full production .... (R)

IF NO:

Loss in turnover since the flood until in full production ....(R)

Was the loss in turnover suffered during and immediately after the flood recovered? .... YES | NO

State the percentage of profit normally taken on turnover ....

Remarks: ____

____

I. Other losses in income (e.g. salaries)

Specify type of loss	Number of persons	Number of working days	Wages per day (R)	Total loss (R)
			Total (R)	

Was any compensation received? | YES | NO |

IF YES:

Amount claimed .... (R)

.... (R)

Amount received .... (R)

.... (R)

Name of institution ....

....

J. Loss in rent

Was any loss in rental payments suffered? | YES | NO |

IF YES:

Period (months) ....

Amount (per month) .... (R)

Total loss .... (R)

Was any compensation received for the loss in rental payments? | YES | NO |

IF YES:

Amount received .... (R)

.... (R)

Name of institution ....

....

K. Assistance rendered to other flood victims during the flood (e.g. transport, evacuation, accommodation and food)

Type of assistance	Vehicles			Number of labourers		Labour hours		Cost per hour		Total Value (R)
	Type	Distance travelled	Cost (R)	Skilled	Unskilled	Skilled	Unskilled	Skilled	Unskilled	
									Total (R)	

L. Additional accommodation cost incurred

Kind of accommodation	Number of persons	Period	Total value (R)
		Total (R)	

Was any compensation received? | YES | NO |

IF YES:

Amount claimed .... (R)

.... (R)

Amount received .... (R)

.... (R)

Name of institution ....

....

M. Savings on expenditure (e.g. wages and rent) during the time of flood

Item	Value (R)
Total (R)	

N. Other costs and damages as a result of the flood not yet mentioned (e.g. electrical rewiring and storage cost)

Type	Amount (R)
Total (R)	

O. Death or illness as a result of the flood

Drownings		Illness and injuries	
Number	Funeral cost (R)	Number treated	Amount (R)

P. Other flood assistance received

Institution	Subsidy (R)	Donation (R)	Insurance payment (R)	Loan			Purpose
				Amount (R)	Period (years)	Rate of interest	

Q. Other flood information

For how long a period was telephone communication interrupted? ____________

By what amount was the telephone account higher/lower as a result of the flood? ______

For how many days were children absent from school? ____________

How many children were affected? ____________

Did you receive any warning concerning the approaching flood? YES | NO

IF YES:

How long before the flood reached the property? ____________

Were any precautionary measures taken? (e.g. evacuation) YES | NO

IF YES:

State kind of precautionary measures ____________

____

In case of evacuation state the percentage of removable goods that were removed ______

Cost of precautionary measures (R) ____________

Could any of the damages suffered be prevented if the warning was received a day earlier. YES | NO

IF YES:

Items	Value of damage that could be avoided (R)
Total (R)	

IF NO:

State reasons why not: ______________________________

____

____

Suggestions to improve the warning system: ______________________________

____

____

____

R. Damage to animals (death, loss, injury, disease)

Kind of animal ....

Number dead or lost ....

Total value ....(R)

Was any compensation received? (YES OR NO) ....

IF YES:

Amount claimed .... (R)

.... (R)

Amount received .... (R)

.... (R)

Name of institution ....

....

Number of animals treated against disease or injuries as a result of the flood ....

Kind of animal ....

Veterinary and medicine cost .... (R)

QUESTIONNAIRE TO DETERMINE FLOOD DAMAGE ON FARMS AND SMALL HOLDINGS

Name and address of OWNER ______________________________

Telephone number ______________________________

Name and address of TENANT ______________________________

Telephone number ______________________________

Name of irrigation board,
syndicate or private property ______________________________

Numbers of damaged farms or small holdings that were damaged ____________

ENUMERATOR ______________________________

Record No. [| | |]

Area No. [|]

Down stream Nr. [| | |]

Total area of farm (ha) ____________

Total delimitated irrigation area (ha) ____________

<u>NB</u> ASK FARMER TO INDICATE FLOOD LINE ON HIS FARM MAP

DAMAGE TO LAND	Grazing land	Dry land	Irrigation land	Vineyard and orchard	Yard and private garden
Area inundated (ha)					
Area inundated where land shows <u>LITTLE</u> OR <u>NO</u> signs of damage (ha)					
Area inundated where damaged land is <u>RESTORABLE</u> (ha)					
Area inundated where land is <u>IRRESTORABLE</u> (ha)					
Area of grazing land already irrestorably damaged before the flood (ha)		X	X	X	X

For areas with <u>NO</u> OR <u>LITTLE</u> flood damage state:					
Average depth of inundation (m)					
Hours inundated					
Cleaning up expenses (R)............................					

DAMAGE TO LAND (continued)

	Grazing land	Dry land	Irrigation land	Vineyard and orchard	Yard and private garden
For area RESTORABLY damaged, state:					
Average depth inundated (m)					
Hours inundated					
Area to be restored (filled up and/or levelled) (ha)					
Actual or estimated restoration and cleaning up expenses:					
for portion done by farmer himself (R)					
for portion undertaken by contractor (R)					
Area at least 6" higher after restoration than before the flood (ha)	X				X
Area at least 6" lower after restoration than before the flood (ha)	X				X
For area IRRESTORABLY damaged (that is not going to be restored mechanically and which will not recover naturally), state:					
Average depth inundated (m)					
Hours inundated					
Market value of land per ha before the flood (R)					

Briefly describe the nature of damage (e.g. depth washed away and silted up for various areas), as well as reasons for non-restoration of land

DAMAGE TO NATURAL GRAZING

	Sheep		Goats		Cattle		Other	
	Number	Period	Number	Period	Number	Period	Number	Period
	SSU	Months	SSU	Months	LSU	Months		Months
Number of livestock reduced as a result of the flood								
Market price per unit (R)								

DAMAGE TO CROPS ON DRY AND IRRIGATION LAND (in case of vineyards and orchards refer to p. 79)

State degree of damage to land (nil, resorable or irrestorable)						
Type of land (dry or irrigation)						
Is land situated along inner or outer turn of river or where river flows straight						
Type of crop concerned						
Age of crop (weeks after germination)						
Direction of rows (diagonal or with stream)						
Area of crop flooded where HARVEST:						
was reaped before flood (ha)						
was not fully reaped before flood (ha)						
For area flooded where harvest was not fully reaped, state:						
(i) Area with NO damage to harvest (ha)						
Portion of harvest reaped before the flood						
Average depth inundated (m)						
Hours inundated						
(ii) Area where harvest was PARTIALLY (regarding quality and yield) damaged (ha)						
Portion of harvest reaped before flood						
Average depth inundated (m)						
Hours inundated						
Percentage of harvest loss due to superfluous rain						
(iii) Area where TOTAL damage to harvest occurred (ha)						
Portion of harvest reaped before the flood ...						
Average depth inumdated (m)						
Hours inundated						
Persentage of harvest loss due to superfluous rain						

DAMAGE TO CROPS ON DRY AND IRRIGATION LAND (continued)

Crop concerned						
For area where harvest was PARTIALLY damaged, state: Yield per hectare during 1974/1975 (ton)						
Manner in which yield was marked:						
Price obtained per ton (R)						
Total income (R)						
For area where harvest was PARTIALLY and TOTALLY damaged: Normal yield per ha (ton)						
In which manner would yield have been marked under normal circumstances						
Expected price per ton (R)						
Total expected income (R)						
Crop insurance payment received (R)						
Production cost incurred after flood up to harvesting time per hectare (R)						
Average annual production cost per ha under normal circumstances (R)						
Nett annual loss per ha (R)						
For perennial crops: Area where CROP was totally damaged (ha)						
Area where CROP has been re-established (ha) .						
Cost of re-establishment (ha) (R)						
For area not re-established, state reason						

DAMAGE TO CROPS ON DRY AND IRRIGATION LAND (continued)

Detail about extra harvests during year of flood which would normally not have been gained

Type of crop	Area (ha)	Yield per ha (ton)	Income per ha (R)	Production cost per ha (R)	Remarks

Detail concerning loss in income from crops not planted or planted too late because of the flood

Type of crop	Should the year have been normal					As a result of the flood		
	Area planned to be planted (ha)	Expected yield per ha (ton)	Expected price per ton (R)	Production cost per ha (R)	Area planted (ha)	Yield per ha (ton)	Price per ton (ha)	Production cost per ha for the year (R)

For crops not inundated but which could not be irrigated in time, state:

Type of crop	Area that could not be irrigated in time (ha)	Loss in yield per ha (ton)	Loss in income per ha (R)	Cost savings per ha (R)	Explain causes of damage

Increased weed control expenses after flood

Area of weed control (ha)	Total weed control expenses before flood (R)	Total weed control expenses after flood (R)	Give detail regarding increased weed control expenses

DAMAGE TO VINEYARDS AND ORCHARDS

State degree of damage to soil (nil, restorable or irrestorable)								
Is land situated along inner or outer turn of river or where river flows straight								
Type of crop concerned								
Grape variety								
Trellis system for vineyard								
Age of crop (year)								
Direction of rows (Diagonal = D or With = W)								
Area of crop flooded where <u>CROP</u>:								
(i) Was not washed away or damaged, did not die (ha)								
Average depth inundated (m)								
Hours inundated								
(ii) Did not die or was not washed away <u>but</u> was damaged (ha)								
Average depth inundated (m)								
Hours inundated								
Has been re-established (ha)								
Re-establishment cost per ha (R)								
(iii) Died or washed away (ha)								
Average depth inundated (m)								
Hours inundated								
Has been re-established (ha)								
Re-establishment cost per ha (R)								
Reasons for portion not re-established								
In the case of orchards, number of trees dead or washed away								

DAMAGE TO VINEYARDS AND ORCHARDS (continued)

Crop concerned								
Area of crop flooded where HARVEST:								
Was non-existant (crop as yet not bearing) (ha)								
Was reaped before flood (ha)								
Was not reaped before flood (ha)								
For area flooded and not fully harvested, state:								
(i) Area with NO damage to harvest (ha)								
Portion of harvest reaped before the flood								
Average depth inundated (m)								
Hours inundated								
(ii) Area where harvest was PARTIALLY (regarding quality and yield) damaged (ha)								
Portion of harvest reaped before the flood								
Average depth inundated (m)								
Hours inundated								
Percentage of harvest loss due to superfluous rain								
(iii) Area where TOTAL damage to harvest occurred (ha)								
Portion of harvest reaped before the flood								
Average depth inundated (m)								
Hours inundated								
Percentage of harvest loss due to superfluous rain								
For area where harvest was PARTIALLY damaged, state:								
Yield per hectare during 1974/1975 (ton)								
Manner in which yield was marketed								
Price obtained per ton (R)								
Total income (R)								

DAMAGE TO VINEYARDS AND ORCHARDS (continued)

Crop concerned								
For area where harvest was PARTIALLY and TOTALLY damaged, state:								
In which manner would yield have been marketed under normal circumstances								
Yield per hectare under normal circumstances (ton)								
Expected price per ton (R)								
Total expected income (R)								
Production cost incurred after flood up to harvesting time per ha (R)								
Average annual production cost per hectare under normal circumstances (R) ..								
Average annual nett farm income per ha (R)								
In cases where crop DIED or was DAMAGED, state estimated loss of production or income per ha, if crop was not replaced								
1976								
1977								
1978								
1979								
1980								
1981								

Explain how loss of production or income was determined ______________________________

____

____

____

DAMAGE TO PLANTS IN PRIVATE GARDEN

Type of plant damaged	Estimated or real cost to restore to pre-flood condition or to replace (R)	Description of damage
Total		

DAMAGE TO BUILDING

I RESTORABLY DAMAGED BUILDINGS (residences, outbuildings, barns, pump-houses, labourer's houses, etc.)

Type of building								
Number damaged								
Depth of inundation (m)								
Hours inundated								
Age (years)								
Floor area (m^2)								
Number of bedrooms in the case of residences								
State type of material used for building (state nature of bricks, mortar, plastering and roof)								
Value of building prior to flood, considering age and condition (R)								
Cost to erect same building immediately prior to flood (R)								
<u>If buildings were repaired:</u>								
Number repaired								
Repair cost for work done by farmer himself:								
Roof (R)								
Walls (R)								
Floors (R)								
Ceiling (R)								
Total (R)								
Repair cost for work done by contractor:								
Roof (R)								
Walls (R)								
Floors (R)								
Ceiling (R)								
Total (R)								
Cleaning up expenses (R)								

DAMAGE TO BUILDINGS (continued)

Type of building						
Floor area after reparation (m^2)						
If building was not repaired:						
Number not repaired						
Floor area of those not repaired (m^2)						
Estimation of repair cost if done by farmer himself (R)						
Side effects (e.g. cracks in building, peeling off of paint)						
Specify						
Repair cost or estimate .... (R)						
Has amount already been incorporated in previous repair cost?						

II BUILDINGS IRREPARABLY DAMAGED (residences, outbuildings, barns, pump-houses, labourer's houses, etc.)

Type of building						
Number damaged						
Depth of inundation (m)						
Hours inundated						
Age (years)						
Floor area (m^2)						
Number of bedrooms in the case of residences						
Type of material used for building (state type of bricks, mortar, plastering and roof)						
Value of building prior to flood, considering age and condition .... (R)						
Cost to erect same building immediately prior to flood (R)						
Demolition value .... (R)						
Cleaning up expenses .... (R)						

DAMAGE TO BUILDINGS (continued)

<u>If building was replaced:</u>

Type of building							
Number replaced							
Cost of work done by farmer himself	(R)						
Cost of work done by contractor	(R)						
Floor area after replacement (m^2)							

<u>If building was not replaced:</u>

Number not replaced							
Floor area of those not replaced (m^2)							
Estimation of replacement cost if done by farmer himself	(R)						

What precautions against future floods were taken after the flood with respect to buildings?

DAMAGE TO FIXED IMPROVEMENTS (e.g. soil conservation works, irrigation works, fences and windmills)

Type of improvement damaged						
Age						
Number inundated						
Number partially damaged						
Number totally damaged						

DAMAGE TO FIXED IMPROVEMENTS (continued)

Type of improvement damaged ....

Length flooded (m) ....

Length totally damaged (m) ....

Length partially damaged (m) ....

Average depth of inundation (m) ....

Value of damaged item prior to flood considering age and condition .... (R)

(NB Give value per unit or per metre length etc. as applicable and indicate unit) ....

Physical description of damaged items (e.g. type of material and dimensions)

When totally damaged:

Number replaced ....

Length replaced (m) ....

Cost of replacement done by farmer himself .... (R)

Cost of replacement done by contractor .... (R)

Total damage (continued)

Percentage improvement (i.e. extension or reinforcement, not renovation) on the old one

Estimation of replacement cost (if done by farmer himself)of part not replaced .... (R)

Reason for not replacing ....

When partially damaged:

Number repaired ....

Length repaired (m) ....

Cost of repair work done by farmer himself .... (R)

Cost of repair work done by contractor .... (R)

DAMAGE TO FIXED IMPROVEMENTS (continued)

Type of improvement damaged							
Percentage improvement (i.e. extension or reinforcement not renovation) on the old one							
Estimation of repair cost of that portion not repaired when done by farmer himself	(R)						
Reason for not repairing							

Remarks: ____

____

____

____

____

DAMAGE TO HOUSE CONTENT (e.g. kitchenware, diningroom equipment and other furniture and equipment)

Item damaged	Year bought	Price Paid (R)	Value before flood (R)	Real or estimated repair cost if repairably damaged (R)	Real or estimated replacement cost with something similar if irreparably damaged (R)	Age of replacement item	Percentage improvement on old item	Remarks on improvements and on sentimental or antique items
Total	X	X				X	X	

NB What percentage of house content was removed before the flood? ______________________

DAMAGE TO STOCK (e.g. fertiliser, seed, feedstuff, fuel, oil and bags)

Item damaged	Number (State unit)	Evaluation of damage (R)	Item damaged	Number (State unit)	Evaluation of damage (R)
			Total (R)	X	

DAMAGE TO PROPERTY OF LABOURERS

Item damaged	Value (R)
Total (R)	

DAMAGE TO VEHICLES, IMPLEMENTS AND MACHINES

	Repairably damaged						Irrepairably damaged					
Item damaged or lost												
Capacity												
Age (year)												
Number												
Value of item before flood .... (R)												
Estimated or real repair cost if reparably damaged .... (R)							X	X	X	X	X	X
Estimated or real replacement cost if irreparably damaged .... (R)	X	X	X	X	X	X						
% improvement of new on old one ..												
Age of replacement item												

Remarks: ____

____

____

____

____

DAMAGE TO LIVESTOCK (DEAD, LOST, INJURED, DISEASE CONTROL)

Type of animal						
NUMBER DEAD OR LOST						
Under the age of 1 year (grade)						
(stud)						
One year and older (grade)						
(stud)						
Total market value (R)						
NUMBER OF STOCK TREATED FOR DISEASE OR INJURIES AS A RESULT OF THE FLOOD: (NB NOT AS A RESULT OF SUPERFLUOUS RAIN)						
Under the age of 1 year						
One year and older						
Veterinary and medicine cost (R)						
LOSS IN INCOME BY PRODUCING ANIMALS (E.G. MILK, EGGS):						
Type of animal						
Type of product						
Period during which loss occurred (days)						
Quantity of product						
Loss in income (R)						
Expenses needed to maintain normal income (R)						

ADDITIONAL FEED BOUGHT

Type of feed	Quantity	Value (R)	Reason for feed purchase (e.g. to replace damaged natural or artificial pasture)

COSTS WITH THE TRAVELLING OF DETOURS AND ADDITIONAL TRIPS AS A RESULT OF THE FLOOD (E.G. WITH TRACTORS, TRAILERS, TRUCKS AND MOTOR CARS)

Type of vehicle						
Capacity of vehicle						
Additional kilometers travelled during and after flood						
Period (days) during which detours had to be travelled						
Vehicle cost per kilometer or per hour (c)						
Speed in kilometer/hour						
Number of adults involved:						
Household members						
Labourers						
Cost per hour:						
Household members (c)						
Labourers (c)						
Total vehicle costs (R)						
Total labour costs (R)						

FLOOD AID RECEIVED

Purpose of aid	Institution	Subsidy (R)	Donation (R)	Insurance payments (R)	Loan		
					Amount (R)	Term years	Rate of interest
Damage to land							
Damage to crops and harvests							
Damage to buildings							
Damaged to fixed improvements							
Damage to house content							
Damage to vehicles, implements and machines							
Damage to stock							
Damage to labourers property							
Livestock losses							

AID RENDERED TO OTHERS (e.g. accommodation, repair of land, food, clothing, cash and transport)

Nature of aid	Value (R)
Total (R)	

LOSS OF LIVES, ILLNESS AND INJURIES AS A RESULT OF THE FLOOD

Drownings		Illness and injuries	
Number	Funeral costs (R)	Number treated	Amount (R)

FLOOD PRECAUTIONS AND AFTER-CARE (EG. EVACUATION OF ANIMALS, FURNITURE, SUPPLIES AND PUMP INSTALLATIONS; ERECTING OF TEMPORARY EMERGENCY EMBANKMENTS; STACKING OF SANDBAGS AND CLOSING UP OF DOORS)

	Precautions				After-care			
Type of precaution and after-care								
Number of household members involved								
Number of labourers involved								
Time taken up (hours)								
Tractor hours involved								
Kilometers travelled with lorries								
Kilometers travelled with trucks								
Kilometers travelled with motor cars								
Cost per hour: Household members (c)								
Labourers (c)								
Cost per kilometer: Tractor (c)								
Lorry (c)								
Truck (c)								
Motor car (c)								
Material cost (R)								

OTHER FLOOD DAMAGE INFORMATION

State loss sustained to other farming activities not directly influenced by the flood, because timely attention could not be given to these activities on account of the flood

Farming activity	Detail of damage	Amount ascribed to flood (R)
	Total (R)	

OTHER FLOOD DAMAGE INFORMATION (continued)

How many days was the road from your farm to the nearest service centre closed due to flooding? ______________________

How many days was telephone communication cut off from the outside world? ______________________

Which amount was your telephone account higher (lower) due to the flood (specify higher of lower)? ______________________

How many days were your children absent from school? ______________________

How many children were involved? ______________________

Which amount electricity costs were incurred (cutting off and connecting up) and to repair the system on your farm? ______________________

State costs to replace or repair drinking water system ______________________

State costs to replace or repair sanitary system ______________________

State costs connected with extra housing ______________________

Give an outline of the above-mentioned cost calculation ______________________

WARNINGS

Did you receive any warning about the approaching flood? YES | NO

How many hours before the flood waters reached your farm? ______________________

Could any of the damage suffered have been avoided should you have received the warning one day earlier? YES | NO

WARNINGS (continued)

IF YES:

Items on which damage could have been avoided	Value of damage that could have been avoided R
Total (R)	

IF NO: Give reasons why not

Do you have any suggestions on the improvement of the warning system?

INTANGIBLE DAMAGES

Give a description of intangible damages suffered (e.g. fear, discomfort and environmental disruption)