resources may be achieved by the strategy of preserving and restoring the flood plain's natural functions, for example, by regulating land-use. For each of these strategies there is a range of risk management tools described below.

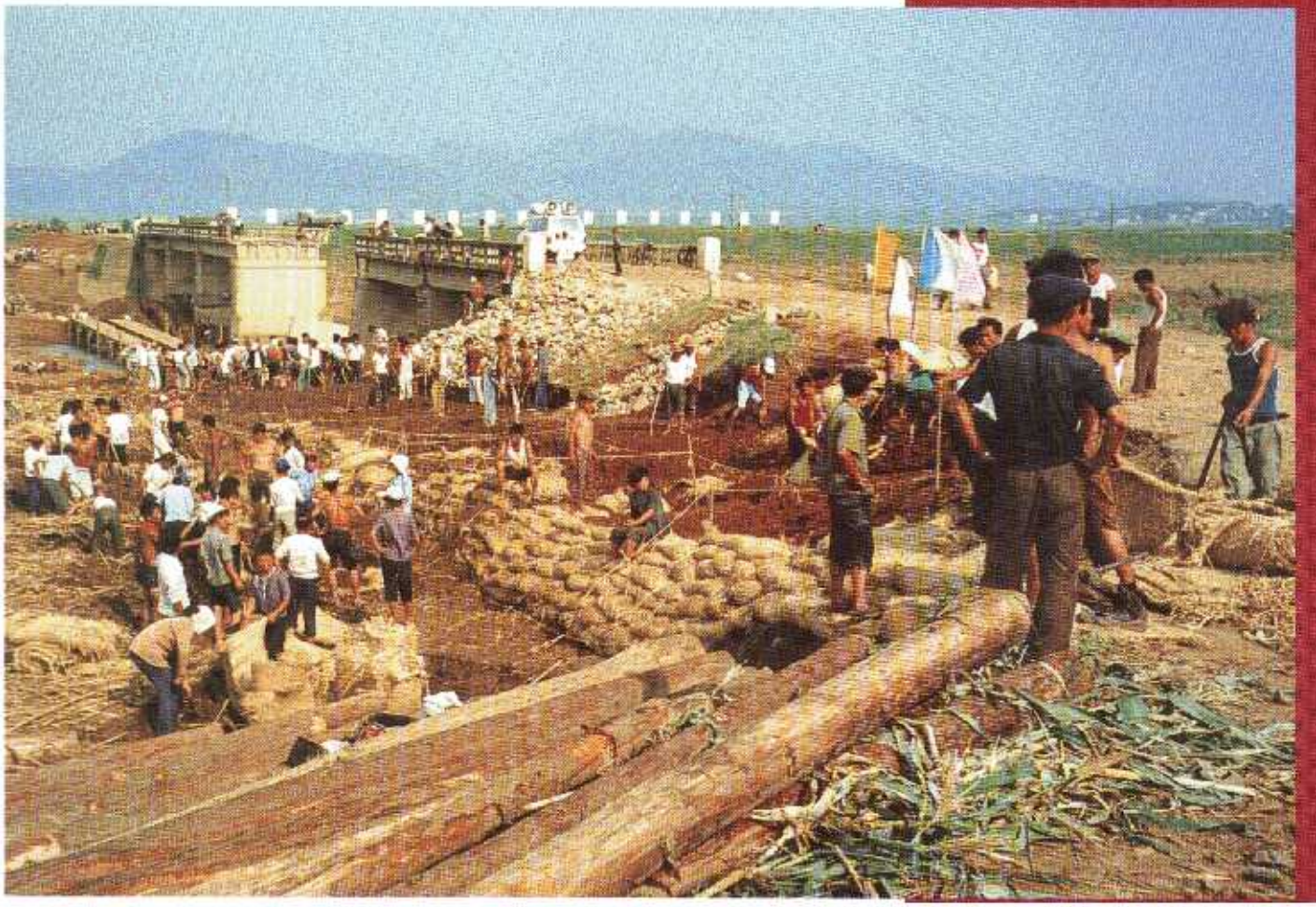
For any particular flood plain there are a variety of conditions to be taken into account by decision makers as they try to achieve this compatibility. The mix of strategies adopted for management will depend on the physical and natural conditions of the flood plain, existing land-uses and developments and, in addition, on a whole range of external factors including societal values and legal constraints. Flood plain management is thus a decision-making process that seeks sustainable use of the flood plain lands and waters.

Strategies for reducing loss of life and property

Thomas's three strategies are listed in table 2, together with the tools available to implement them. Each strategy requires actions before the flood, during the flood and after the flood. All three strategies need to be considered in the management of a flood plain.

Reducing the flood concentrates largely on so-called structural measures including the construction of dykes, flood banks or levees to divert the flood waters; dams and reservoirs to retain flood waters upstream; and channel improvements to evacuate flood waters more rapidly. These structures have to be

Floods in China DHA. O. Almgren



Floods in Jamaica 1979.
J. S. Tyndale-Biscoe

STRATEGY I: REDUCE FLOODING

Dams and reservoirs
Dykes, levees, flood banks
Channel improvements
High flow diversions
Land treatment measures
On-site detention

STRATEGY II: REDUCE SUSCEPTIBILITY TO DAMAGE

Flood plain regulations
Zoning
Subdivision regulations
Building codes
Housing codes
Sanitary codes
Other regulations

Development and redevelopment policies
Design and location of facilities
Land rights, acquisition and open space
Redevelopment
Permanent evacuation

Flood proofing
Flood forecasting and warning systems

STRATEGY III: REDUCE THE IMPACT OF FLOODING

Information and education
Disaster preparedness
Disaster assistance
Flood insurance
Tax adjustment
Flood emergency response
Post-flood recovery

STRATEGY IV: RESTORE AND PRESERVE THE NATURAL AND CULTURAL RESOURCES OF THE FLOOD PLAIN

Flood plain and wetland regulations
Zoning
Subdivision regulations
Building codes
Housing codes
Sanitary codes
Other regulations

Development and redevelopment policies
Design and location of facilities
Land rights, acquisition and open space
Redevelopment
Permanent evacuation

Information and Education
Tax adjustments
Other administrative measures

Table 2 Strategies and tools for flood plain management. (Modified from Thomas, 1995)

built before the flood, but need proper operation and safeguarding during the flood and perhaps repair after the flood. Structural measures have proved very effective in saving life and property, but they are often expensive, both to build and maintain, and nowadays meet environmental objections. An advantage of structural methods is that they can be effective in protecting existing developments on the flood plain. In contrast, many non-structural measures may only benefit new developments. Structural measures are discussed in more detail in chapter 4 below.

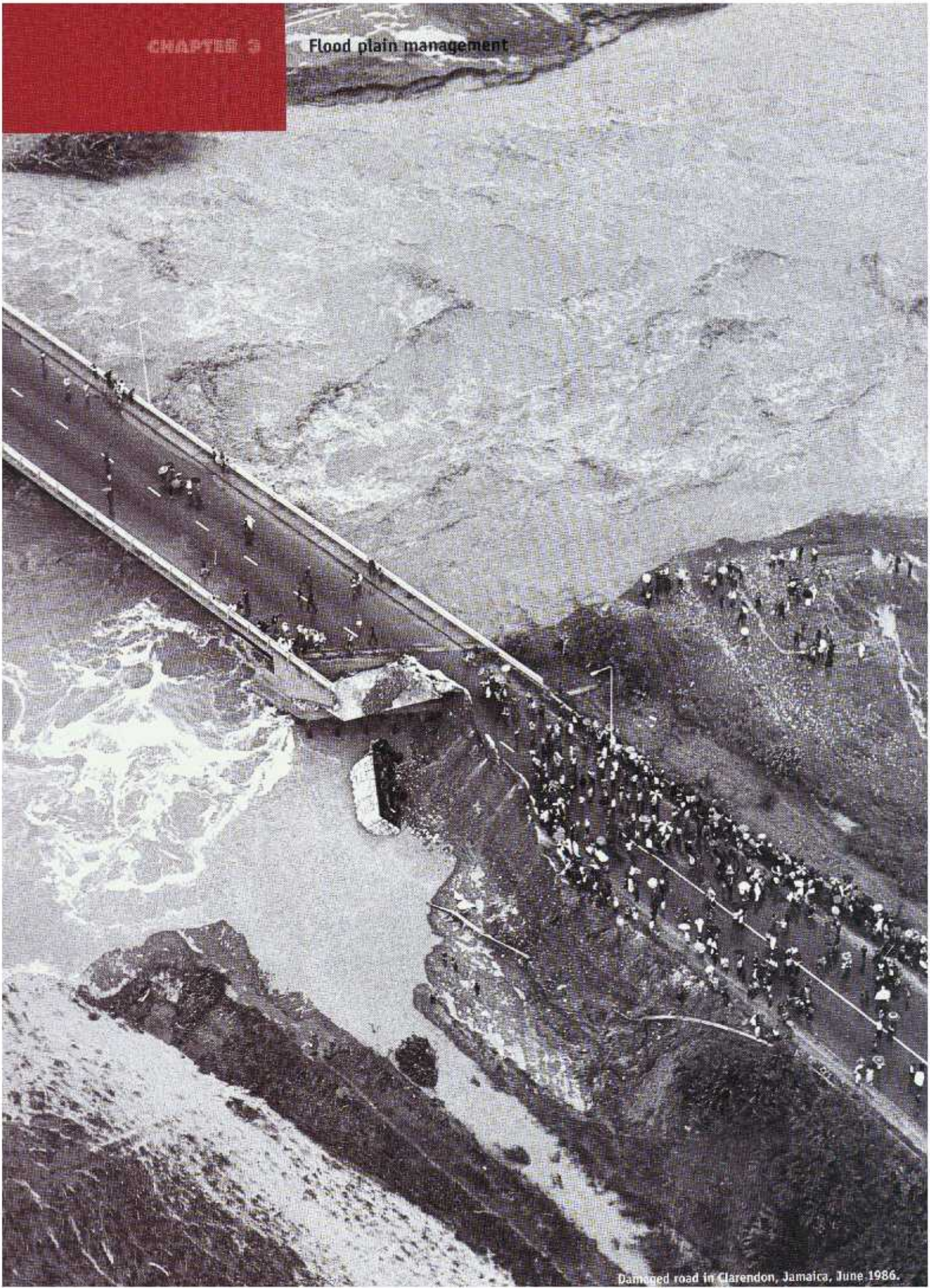
Hai an-Dam: fighting the floods.
Photo by Y. Yi-Qiu

The strategy of reducing susceptibility to flood damage strives to avoid dangerous, uneconomic or otherwise undesirable use of the flood plain. This is accomplished by land-use planning regulations, development policies, raising buildings above flood levels, and flood-proofing of buildings. These non-structural measures can be very effective in keeping new development out of the way of floods, but they afford little protection for existing developments and for the natural and cultural resources of the flood plain. They can be unpopular. Planning regulations and policies preventing development are seen as reducing land values, which can lead to legal claims for compensation. Flood forecasting and warning systems are also important for reducing losses by giving the affected population time to take precautions such as moving goods and furniture above the forecast flood level, reinforcing flood defences or evacuating. These measures all need to be set up long before the flood occurs and it may be difficult to maintain them in force if there is a long interval between damaging floods. Chapter 5 describes these non-structural measures in more detail.

When, despite the precautions taken, a flood does occur, an efficient and effective emergency response system is needed to provide both immediate and post-disaster assistance to the victims. The population at risk needs to be informed in advance of the steps that will be taken emergency evacuation, temporary shelters, etc.-and of the arrangements for setting them in motion. Assistance with post-disaster recovery will be needed and this may be provided by flood insurance or special disaster relief funds. The opportunity needs to be taken after each emergency to reinforce the information provided to the public and, of course, to review the operation of the relief system. Chapters 5 and 7 deal with these measures.

CHAPTER 3

Flood plain management



Damaged road in Clarendon, Jamaica, June 1986.