PART B

AN APPLICATION OF RADAR TO HURRICANE MITCH

HONDURAS, OCTOBER 1998

CHAPTER 5

INTRODUCTION

A very strong hurricane hit the Caribbean coast of Honduras in the last week of October 1998. At the end of January 1999, about three months after the event, an FAO-WFP report on Honduras (FAO-WFP, 1999) concluded with the following:

> "Hurricane Mitch, which swept across Honduras, Nicaragua and neighbouring countries early in the week of 27th October [1998] is considered to be the worst natural disaster in recorded history to hit Central America. Honduras suffered more than its neighbours, because, after sweeping across the country, the hurricane became stationary off the Caribbean coast of Honduras, resulting in torrential rains, flooding and landslides that killed over 7 000 people and left another 8 000 people missing. In all about 276 000 families were affected by the hurricane and over 600 000 people were evacuated. In addition to the loss of life, extensive damage to infrastructure, including destruction of houses, roads and bridges, and severe damage to the agricultural sector were sustained. About 310 000 hectares were affected, with damage estimated at US$ 881 million. Losses, owing to loss of land fertility, have been estimated at US$ 400 million. ... The greatest hurricane damage occurred in the northern areas, where the hurricane entered the country, and along the path of the hurricane as it moved south across Francisco Morazan to the southern areas.
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> "The mission observed two types of damage. First, major damage was concentrated along many river valleys, as the water levels rose to record heights. Second, landslides, which were localized, were common in upland areas and especially in deforested areas. The extent of the damage to crops and livestock varied greatly with location: from total destruction of some villages, which were in the path of rising flood waters or covered by landslides on steep upland areas, to only slight damage caused by heavy rains on the fringe of the hurricane. This great variation in the extent of damage presented the Mission with the difficult problem of estimating overall damage throughout the country. The damage was severe in some areas, but not total throughout the country.
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> "The Mission's evaluation of crop damage is based on field visits to hurricane-affected areas in the south (Department of Choluteca) and in the north of the country (Litoral Atlantico); discussions with government officials concerned (Secretary of Agriculture and Livestock, and Secretary of Finance) and representatives of the private sector (CONNPAH); meetings with donor representatives, including USAID and the

European Union; and contacts with non-governmental organizations (CARE, CARITAS, Save-the-Children, and others). The Mission also met with other UN agencies, including UNDP, UNICEF and WFP, and with associations of producer cooperatives, which provided the opportunity to examine production trends, trade, stocks and other data. The Mission visited numerous markets in different towns and villages to assess the availability of food and to determine prices."

While the description above gives an adequate idea of the general nature of the disaster, it does not assess quantitatively the physical aspects of the event in various regions (Departments) of the country. For the impact of the hurricane on food security, a FAO publication provides a good summary (FAO, 2001).

In Part B of this report, a worked example of disaster impact assessment for Hurricane Mitch is described in detail to show the validity and practicality of the approach proposed in Part A. It should be noted that much of the data needed to adequately apply RADAR has never been collected and the present example can consider only a limited sample of the environmental elements involved in the region of impact.

CHAPTER 6

THE EVENT, ENVIRONMENT, AND MILIEU

6.1 DEFINITION OF THE PHYSICAL EVENT

One of the sources of general information that reports the physical aspects of the hurricane is the Centre for Integrated Natural Disaster Information (CINDI) of the US Geological Survey (USGS), which in collaboration with the National Oceanic and Atmospheric Administration (NOAA) gives an account of the event at 3–6-hour intervals. They report position, wind speed, pressure and the Simpson intensity scale for the hurricane (see Figure 6.1 on p. 71 for the hurricane path). Hurricane Mitch started as tropical storm in the southern Caribbean Sea on 22 October 1998, and headed north. After turning WNW at the latitude of the northern coast of Honduras, it became a scale-5 hurricane on 26 October, when it was 150 km north of the coast. As it turned south toward the land, it hit the Islas de Bahia Department of Honduras as a scale-4 hurricane on the 28th. The next day (29 October), it entered the northern coast of Honduras, rapidly decreasing in intensity from a scale-2 hurricane to a tropical storm. After sweeping across Honduras from east to west, it entered Guatemala on 31 October, continuing toward Mexico. Thence Hurricane Mitch headed north again to the Caribbean coast and then NE toward Florida, USA.

6.2 THE REGION OF IMPACT

The first step in the disaster impact assessment procedure is to identify the region and area affected by Hurricane Mitch. The definition of the region of impact is relatively simple once the extent of the physical event is known in adequate detail. A number of maps, in addition to the one showing the track of the hurricane, that describe in sufficient detail the region of impact can be found at CINDI. According to these sources, the region affected by Hurricane Mitch covers almost all Central America, including Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua.

The infrastructure map shows that there is a fairly dense, homogeneous distribution of villages, apart from the Atlantic coast, where density decreases to almost nil. The largest number of main electricity power lines are located in Guatemala, Nicaragua and Salvador, with very few in Honduras, the country that was swept across from east to west by Mitch. Thus, to

attempt a first-order approximation, it is expected that most of the damage will be concentrated on the villages, roads and bridges of Honduras. Southern El Salvador, northern Nicaragua and Guatemala have also been affected, but with less impact.

6.3 THE AREA FOR IMPACT ASSESSMENT

The data presented in the preceding sections show that the greatest loss was suffered by the country of Honduras. Thus, one should limit the *area* over which to estimate the impact to that country. This decision is not irrelevant, nor obvious, and a similar study could be implemented for areas affected in Nicaragua or Guatemala. The choice of this area is a compromise forced by the fact that agricultural production DBs are structured by country and also often by Departments within a country. Production is averaged over countries (and departments), and therefore there are no point-specific sources of information on agricultural production, which would be the optimal data set.

In fact, there is a dichotomy between the actual physical data of a destructive event, which can be obtained, in principle, spatially over the whole region of impact through a point-specific structure, and the agricultural production data that is usually stored by discreet surface units (either by country or by Department). This dichotomy would not be a problem if each surface unit (country or Department) were affected in the same way and intensity by the same type of event, which is of course highly unlikely.

Once the area of Honduras has been identified for the impact assessment, a number of data and thematic maps could be obtained from a CD produced by USGS-CINDI and the Honduran authorities. This data set is relatively extensive and includes area and population data by Departments, but also holds available agricultural production statistics by Department over the 1990–94 period, at least for the main crops.

6.4 COMPONENTS OF THE MILIEU

6.4.1 Agro-ecological zones

The general map of the ***types of vegetation*** shows that the territory affected is in the tropical evergreen and deciduous forest climatic zones, plus a smaller amount of wet savannah. In fact, a significant part of this territory is used for agricultural activities, as cropping or grazing land. Thus, in general, it is expected that, because of Mitch, much damage will be suffered by the agricultural sectors.

6.4.2 Potential land use and farming systems

The data on Honduras from CINDI-USGS contains an ArcView shape file that shows potential land use. This data set is characterized by extensive subdivision of the territory into areas with different kinds of vegetation and potential use that is far more detailed than is needed for the purposes of RADAR. At the same time, the data set gives no information on actual land use and on crop distribution in 1998, which is the kind of information that effectively would be needed. Thus, the different subdivisions of the potential land use data set can be grouped into five major categories (Figure 6.2 on p. 72):

- **Agua** [water] is areas with permanent water on the surface that contribute nothing to the impact assessment if we are to exclude fishery from the impact assessment.
- **Bosque** [forest] is areas occupied by primary and secondary forest, or left to natural regrowth.
- **Cultivo** [crop land] includes the areas that have seasonal crops (such as maize, rice and dry beans), and also production that tend to be longer term or continuous (such as plantain and banana[22]).
- **Frutal** [fruit trees] includes areas planted with fruit trees and other perennial crops with seasonal production (e.g. orange and lemon groves, coffee or cocoa plantations).
- **Pasto** [pasture] includes all the grazing land dedicated to pasture for livestock (mainly dairy and cattle).

The groups identified above are only a first gross approach towards the precise mapping of the surface distribution of the agricultural production exposed to a disaster, which is what would be needed for disaster impact assessment. One can observe, for instance, that in the proposed land use map, *frutal* areas are almost completely limited to the southern part of Honduras, while in reality fruit trees are more evenly distributed throughout the country. Therefore, since the FAO-GIEWS database[23] contains data for fruit trees in all Departments, the GIS model needs to be adjusted by adding to the former set an artificial *frutal* parcel in those Departments that have none.

As already indicated, the potential land use map, being the only available indication of crop distribution, is one of the elements that limits accuracy in the present impact assessment.

22 Since bananas and plantains are harvested over several cycles, without replanting, these crops could also be considered as semi-perennial.

23 http://www.fao.org/GIEWS/english/index.htm

6.5 THE PARCELS FOR IMPACT ASSESSMENT

The definition of parcels for the impact assessment is a complex task. There is no "correct" or optimal solution to this problem. By definition, a parcel is a fraction of the *area* that may be considered to have equal or similar property values for the milieu components under consideration. Generally, the level of precision for parcel definition is constrained by the form, structure and availability of component-related data.

More specifically, the dichotomy between spatially distributed physical data of the destructive event and agricultural production data, stored by administrative units, is unavoidable. The physical model of the area of impact will be based on the GIS data layers, while agricultural production data, such as obtained from the FAO-GIEWS database, will be stored on a Department-specific basis. In practice, the map of the administrative units will be superimposed with the modelled rainfall map, the flooded areas map, and the potential land use map. The result is a set of 123 parcels (Figure 6.3 on p. 72) that are homogeneous in three parameters: each one belongs to just one Department; was damaged from the same type of event; and has the same nominal land use. The parcels that are small, that is less than 1000 ha, may be an artefact of the GIS elaboration; they are, in any case, too small to contribute significantly to the impact assessment and are neglected. Also, parcels consisting of surface water do not contribute to the impact assessment and can be assigned an impact of $ 0. Thus, the working set is reduced to 103 parcels. For each of these parcels, the total area (ha), the number of villages and the population are known.

6.6 THE COMPONENTS OF THE MILIEU OF EACH PARCEL

In the present example, there are five parcel categories (*agua, bosque, cultivos, frutal* and *pasto*). For each parcel type, various components of the milieu need to be evaluated in relation to hurricane impact. To characterize the components of the milieu, the relevant elements are identified by system for each parcel (Table 6.1). *Agua* has been ignored as being of no significance for the present purpose.

The proposed component choice is presented mainly to illustrate an application of RADAR to a real case. It is not the only possible one, nor absolutely optimal, but is a compromise between the peculiarities of the area affected and the information available on agricultural production.

6.7 CONCEPTUAL MODEL

The parcels, once defined, are then used to construct a conceptual model of the area. The model is made by using the elements from a menu of tools. These

TABLE 6.1

Parcel characterization by system category

PARCEL TYPE Bosque	Cultivo	Frutal	Pasto
Resource Systems			
Soil	Soil erosion and sedimentation	Soil erosion	Soil erosion and sedimentation
Trees			
Labour and habitat	Labour and habitat	Labour and habitat	Labour and habitat
Activity Systems			
Timber extraction	Bananas, Plantain, Maize, Rice, Beans (dry), Soybean, Cassava, Potato, Melon, Onion (dry), Sugarcane, Leaf Tobacco	Cocoa, Coffee, Oil palm	Cattle, Dairy
Support Systems			
	Farm buildings	Stores, greenhouses	Cowshed, farm buildings
Machinery and tools	Machinery and tools	Machinery and tools	Machinery and tools
	Input supply (fertilizer, etc.)	Input supply (fertilizer, etc.)	Input supply (feed, etc.)
Access infrastructure	Access infrastructure	Access infrastructure	Access infrastructure
Marketing system	Marketing system	Marketing system	Marketing system
	Agricultural R&D	Agricultural R&D	Agricultural R&D
	Financial services	Financial services	Financial services

elements are icons representing the region, the area, the various parcel types, event intensity, and data links between parcels (Figure 6.4 on p. 73).

The reality of the physical model is simply constructed by generating and positioning the elements over a board. For the Honduras example, given that the agricultural data is structured by administrative units, it is convenient to arrange icons by type and intensity for each Department. Every icon corresponds uniquely to a parcel (Figure 6.5 on p. 73). Thus, by clicking on an icon, one can access the data corresponding to that parcel, for both data input and analysis. The use of the conceptual model, with its much higher degree of abstraction than the physical model, facilitates the management of tasks needed to perform the assessment; the graphic presentation also simplifies its use by non-experts. The model automatically performs calculations, modifications and verifications of impact assessment as needed.

CHAPTER 7

CHARACTERISTICS OF THE EVENT

7.1 CAUSES OF DAMAGE

During the process of impact assessment of a natural disaster, it is of great importance to understand correctly the causes of damage and the interaction of the causes in producing the final damage extent. A careful study of this aspect (clarity of understanding) may frequently allow simplification of the general problem. For instance, if in a given area there is only a moderate destruction of crops due to strong winds of a storm but a total destruction is produced by flooding, the damage produced by the winds can obviously be neglected and only destruction generated by flooding needs to be considered. However, it is a good practice to consider damage produced by all concurring primary events such as wind, surge and spray. In the same way, collateral damage induced by secondary events such as rain, runoff, landslide, flooding, and sedimentation events, should also be combined.

7.1.1 Wind, surge and spray

The available information shows that the hurricane decayed rapidly from an intensity of 5 on the Simpson scale to that of a tropical storm as it approached the land. Wind damage was only possible in the Islas de Bahia Department and along the Caribbean coast of the Colon Department. In these two parts, flooding and torrential rains generated almost total destruction that masked the original wind-related destruction. Thus, in a first approximation, the effect of wind could be reasonably neglected for most of the agricultural impact assessment, although it should be considered in the evaluation of damage to houses along the coast outside the flooded area. Indeed, also in the Departments of Colon (close to the Atlantic coast) and of Islas de Bahia, areas that were not flooded may have been damaged by the wind.

Surge damage is also possible in the same coastal area, although the hurricane-related surge reached, according to the Simpson scale, a maximum of 2 m above the normal high tides on the Caribbean coast. The ultimate result of the surge is equivalent to that of an extremely high tide that inhibits the drainage of the rivers toward the ocean and increases the extent of flooding; thus, the damage produced by the surge is intrinsically incorporated into damage produced by flooding.

Finally, it is assumed that the salty ocean spray is rapidly washed away by the torrential rains, so no direct salt damage would be induced.

7.1.2 Rain, runoff and landslides

The average annual rainfall map (Figure 7.1 on p. 74) for Honduras shows that both the Atlantic and Pacific coasts normally receive about 1400–2000 mm per year of precipitation, while the centre of the region receives much less rain, with a minimum average precipitation of 400–600 mm per year.

The total precipitation map produced by NOAA for Hurricane Mitch shows computer generated rainfall data (Figure 7.2 on p. 75). The three-week precipitation from Mitch was about half the annual precipitation along the coasts, but as much as the annual precipitation in the centre of the region. The NOAA estimate for total rainfall from 25 October to 17 November suggests that in Honduras there are at least three main subareas with regard to the amount of rainfall associated with Hurricane Mitch. Torrential rains (>500 mm) were estimated for the northern and southern parts of the country, while high rainfall (300–500 mm) were recorded for the rest of the country, except for the extreme western part, which was affected by only moderate rainfall (150–300 mm).

Accordingly, within the Departments of Honduras, rainfall and runoff damage was characterized by three different levels of intensities (torrential, high, moderate), corresponding to decreasing amount of damage. Therefore, landslide damage could be considered included into the rainfall damage. Indeed, all other things being equal, as a first approximation, heavier rains will produce more landslides.

7.1.3 Flooding and sedimentation

The CINDI-USGS data on Honduras contains an ArcView shape file that shows satellite radar data. This radar image does not cover the whole country, so the flooded area is incomplete (see pink areas on map in Figure 6.1 on p. 71). In fact, a number of areas, but most notably the ones in the Gracias a Dios Department, had a much larger flooded area: a rapid comparison of the original radar data with the topographic data allows extension of the flooded areas identified by the radar satellite images to the areas that are more probably similar to the actual situation (see pink and red areas in Figure 6.1 on p. 71).

It is assumed that the damage produced by both flooding and sedimentation is maximum, and for most crops the damage would correspond to total destruction, although some types of tropical forest may survive flooding without major damage. Finally, sedimentation, particularly if mainly consisting of coarse pebbles, may reduce agronomic production potential in the following few years.

7.2 DEFINITION OF A CONVENIENT SCALE OF INTENSITY

The causes of damage described in the preceding section suggest a convenient way to build a simple preliminary scale of intensity (I_p) that can be applied to the Hurricane Mitch impact assessment (Table 7.1). This simple way to build a scale for hurricane intensity in agriculture cannot be extrapolated to other cases without a complete understanding of the specific local conditions. For instance, in the case of Mitch, wind was not a direct source of damage to agriculture, except along the northern coast of Honduras.

TABLE 7.1

Simple scale of rain-related intensity effects

I_p LEVEL	INTENSITY LEVEL
1	Areas affected by 'moderate rains'
2	Areas where 'high rains' occurred
3	Where the rainfall was 'torrential'
4	Flooded areas