

## **THE DEVELOPMENT OF AN EMPIRICAL WORKFLOW PROCESS FOR MAPPING AFFECTED COMMUNITIES OF THE HURRICANE FELIX, NICARAGUA, 2007**

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### **Abstract**

*In September 2007, the Hurricane Felix devastated the North-eastern of Nicaragua, near the Caribbean coast. The hurricane heavily affected about 400 communities from a total of 777 registered in this region. As part of the post-disaster relief measures, INETER (The National Geosciences Institute) in collaboration with other Nicaraguan agencies was requested to elaborate a GIS-based inventory for the analysis of the impact of the hurricane. The information about the affected communities by Hurricane Felix was gathered by the Civil Defence of the Nicaraguan Army. Unfortunate, the field staff had no GPS available, and in the best cases, the national topographic maps have been used to reference the affected settlements. Problems of georeferencing made it necessary to create an empirical workflow process in order to produce the affectation maps using several information sources. This paper describes the approach developed to design a workflow that allows the georeferencing of 64% of the reported sites. The remaining 36% were at least identified as belonging to a certain community in or near the affectation zone indicated.*

### **INTRODUCTION**

The traditional way to produce affectation maps changed dramatically in Nicaragua since the occurrence of the hurricane Mitch in 1998, the largest natural disaster in the country after the infamous 1972 Managua Earthquake [1, 2]. The Hurricane Mitch clearly showed the necessity to produce maps in a rapid manner and since that event the Nicaraguan government has requested the fast production of maps for several disaster management situations.

In response to this demand, INETER (The Nicaraguan Geosciences Institute) started in 2003 to develop a Geographical Information System (GIS) for GeoRisks. After several years of development, this GIS integrates now a large amount of georeferenced information, recollected from several Nicaraguan agencies, ONG's, municipalities, universities and international cooperation projects. In the case of Hurricane Felix, in September 2007, the government requested maps that should show the impact of this hurricane, the several affected communities and the extension of the affected area. As a result, the government created a multiagency working group with the aim of supporting INETER to elaborate the required GIS-based inventory [3].

The challenge was to gather the appropriate data in order to produce the maps showing each affected community and its affectation value. The multiagency working group was actually created some days after the hurricane, and the necessary data was not collected in a proper way. At the beginning of the event, the focus was on the relief support by providing humanitarian help to the population. Most of the agencies worked independently without GPS units. Others have gone to the field and gathered the affected community information but the link

between this information and their exactly geographical locations was missing. The only location information of the communities was georeferenced by the municipality, zone and the community names. Therefore, the main problem turned up to be the difficult and time cost post processing process that could allow the mapping between the location of the affected communities and their affectation information.

This paper describes the approach developed to reach the request of the Nicaraguan government. The main objective is to explain the empirical workflow process developed for mapping the communities as georeferenced points. Moreover, we provide an overview of the agencies and steps that have been taken to reach the final goal of producing impact maps with the affected communities and its affectation values. The results have shown the main role of the developed workflow process in the optimisation and prioritisation of the humanitarian help and the reconstruction plans of the government.

## THE MAIN ROLE OF THE MULTIAGENCY WORKING GROUP

Once the multiagency workgroup was created by the government, several meetings were realised in INETER in order to elaborate the inventory of the impact of the hurricane. Separated activities were organised to be carried out by the primary agency members of the multiagency working group (See Table 1 for a list of agencies). Technical groups were also organised for facilitating data gathering (See Table 2 for the list of agencies involved).

Agency	Role
INETER	National geosciences and mapping institution
CIVIL DEFENSE	Damages evaluation and necessities analysis
MARENA	Ministry of environment and natural resources
INAFOR	Forest institution
MAGFOR	Agriculture and forest agency
NATIONAL POLICE	Nicaraguan police

Table 1 - Agency members of the multiagency working group

Agency	Role
URACCAN	University of the north Atlantic Nicaraguan region
INIDE	National Institute for Statistics (INEC)
SCE	Electoral agency
Health Ministry	Hospitals and health centres
MTI	Infrastructure and transport ministry

Table 2. Other agencies participating in an indirect way for facilitating data

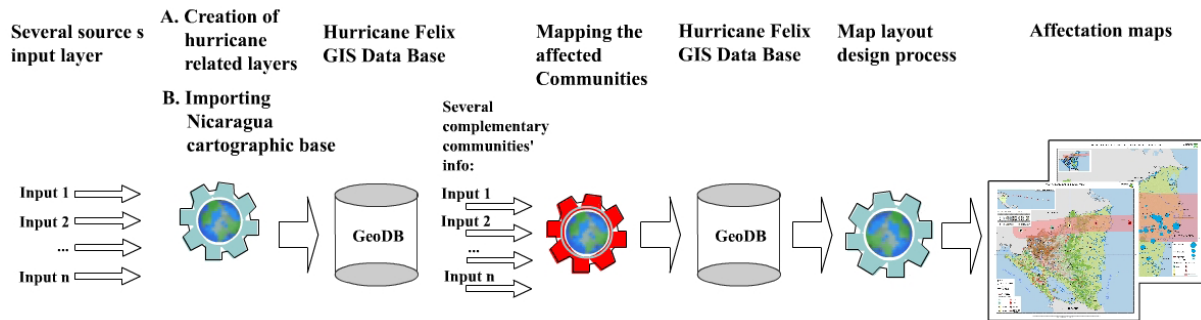
Since the first meeting, the need for a GIS-base data inventory was identified by the executive director of INETER, and the working group had worked towards its execution. The results are summarised in Table 3 below.

Agency	Data available	Georeferenced
INETER	Topographical maps (1:50,000), National Nomenclature DB, GIS cartographic base, Hurricane related information.	Yes
CIVIL DEFENSE	Communities affectation information in spread sheet excel format, without coordinates.	No
MARENA	Satellite images (before event), Forest information and communities' georeferenced layers.	Yes
INAFOR	Destroyed forest information, communities' georeferenced layers.	Yes
MAGFOR	Destroyed forest information, communities' georeferenced layers.	Yes
NATIONAL POLICE	Communities' information.	No
URACCAN	Communities' georeferenced layers.	Yes
INIDE	Information on population distribution and housing	Yes (process to link the data)
SCE	Cartographic images for the 2006 elections	No
Health Ministry	Hospitals and health centers list	No
MTI	Affected and damage infrastructure list	No

Table 3. Inventory of recollected and used data from the participant agencies

## THE MAIN WORKFLOW DEVELOPED FOR PRODUCING THE AFFECTATION MAPS

The main workflow process and the GIS database structure were designed based on the GIS knowledge background of the INETER group. Three main steps have been defined as (a) the creation of hurricane related data layers and a Nicaraguan cartographic base, (b) the mapping of the affected communities, and finally (c) the design of the mapping layout. These steps are illustrated in Figure 1 by using a gear visual metaphor.



*Figure 1. The main workflow process to elaborate a GIS-base inventory.*

In the first step, several sources have been used to generate a first version of the hurricane Felix Geo Data Base (GeoDB). This first GeoDB version had only the essential information which has been easily obtained from sources such as the GIS-GR (Nicaraguan cartographic base maps); the hurricane vector data (e.g. trajectory, category, winds speed), as well as the precipitation raster data obtained from NOAA services. The result generated information layers containing affectation buffers and the precipitation accumulation due to hurricane. The second step consisted of gathering the communities' information data from different sources. This was the most expensive time consuming and resources demanding step of the whole workflow process. The main reason was the missing link between the communities' affectation information and the location or georeferenced information of these communities. Therefore, this step was carried out several times in order to find the correlation between the affectation information with its communities. The output of this second step has generated the version of the GeoDB with all the necessary information to produce the affectation maps. Finally, the third step was the map layout design process which was aimed at the production of the final maps based on the data available at the Hurricane Felix's GeoDB.

## THE APPROACH DEVELOPED FOR GEOREFERENCING

In the process of mapping the affected communities, we were confronted with a large degree of inconsistency, especially in terms of geographical references. Each step in the workflow process described in the previous section was an attempt to build the georeferencing for the communities and produce better and reliable results. Overall, the approach developed was based on eleven phases (Figure 2 and Figure 3). The final phase was concluded during the mapping of most of the communities when was possible to use all the resources available. The phases can be described as one of the following:

- Phase 1: It is the transfer of the text information of affected communities, from the original spread sheet format to the GeoDB table format. This was necessary since the GIS-base inventory was established using the GIS's database structure of GeoDB, and therefore, all the data sets should be in the same GIS layer format in order to allow further spatial analysis. The results were the creation of GeoDB tables containing fields with appropriate information such as the municipality, department and zone to which each community belongs.
- Phase 2: It is the integration of the GeoDB tables generated in the previous phase with the georeferenced communities' layer in order to obtain the first overview of the data displayed on maps. It consisted of performing a join operation between the GeoDB tables and the GIS layer using the Name's field that these data had in common. This was also very useful to identify possible errors occurred during the transfer. Moreover, it was also helpful to verify that just a few communities were joined using the Name field. Most of the affected communities available in the GeoDB tables were unknown communities, and they were not available in the communities' georeferenced layer. In fact, the existing georeferenced communities' layer

was outdated.

- Phase 3: The need to improve the communities' GIS layer, INETER has requested to other Nicaraguan agencies to provide their communities' GIS layers. The results were very satisfactory since MARENA, INAFOR, MAGFOR, and the URACCAN University have provided their own versions of their communities' GIS layer. Consequently, the INETER was able to review the National nomenclature and their names that were used to georeferencing of to the communities. In this phase, the hurricane Felix GeoDB was integrated with all the communities' GIS layers but keeping the information about the source for each community.
- Phase 4: The duplicated communities were removed from the GeoDB, and they have been ordered by name, community, department and zone. As a result of this phase, just a few communities were actually found as the new ones. The problems detected during this phase were related to the syntax of writing the communities' native names. Several communities' names from the different sources were written using different spellings which made difficult the identification of similarity between them. For example, the names of the communities gathered during the field work were not always in accordance with the official names. The fact is that different names were recorded many times inside of the same community or zone.
- Phase 5: A new field was created to be the identifier field for the communities, and it was used throughout the workflow process. This identifier has played an important role in resolving the matching and the syntax problems found in the previous phases. Each community from both sources (i.e. GIS layer and tables) received an ID value, the communities were reviewed one by one, name by name and their geographical position on the map was verified.
- Phase 6: A new join operation was carried out, but this time, using the identifier values of each community. The results have produced a more reliable relation between the GIS layer and tables. However, only 33% of the reported sites in the communities were portrayed on a map. New georeferencing sources were needed, and according to INETER, the two promising sources of data could be the Institute for Statistic and Census (INIDE) and the Supreme Electoral Council (CSE), because both organisations have collected data in 2005 and the end 2006. As a result, both INIDE and CSE have provided the requested data.

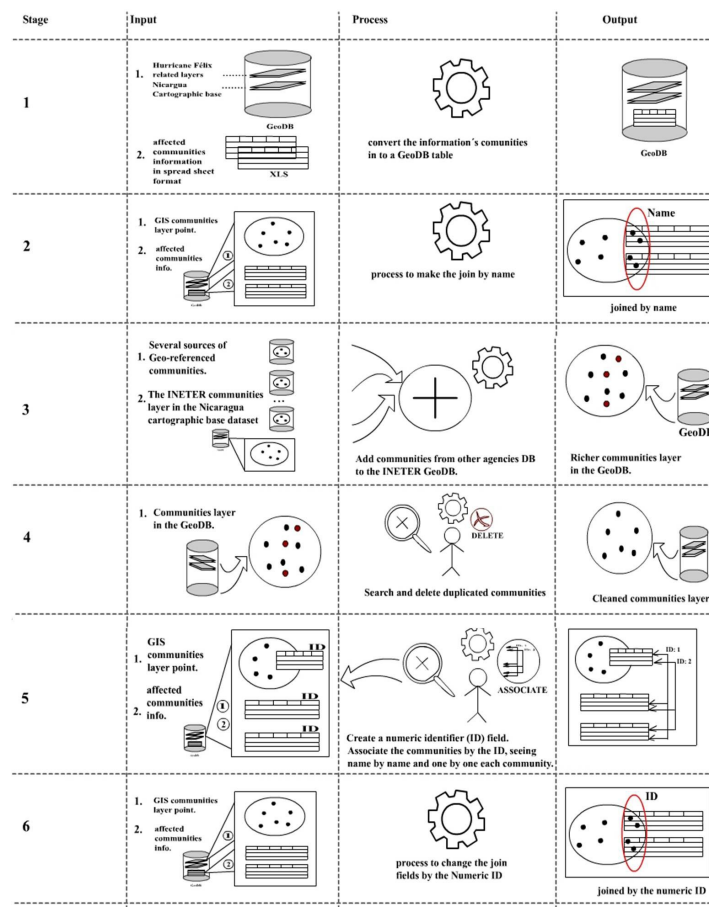


Figure 2. Overview of the georeferencing phases in relation to the workflow process, phases 1 to 6.

- Phase 7: While waiting for the requested information of INIDE and the SCE, we have also used the old but popular Topographic maps of 1988 (scanned and georeferenced) as an alternative source. Therefore, the georeferenced communities of the GeoDB were plotted on this Topo-Maps-88 and the missing communities were searched on these maps based on their municipality, department and zone names. As a result, more communities were found and digitized into the GeoDB.
- Phase 8: Here a new field was added to the GeoDB that indicates the uncertainty of the location of the points. For the actual data in the GIS layer, the value of “0” was assigned to this field indicating that the position of the communities was known. On the other hand, the value “1” was used in the cases that their exact positions were unknown.
- Phase 9: The data provided by the Institute for Statistic and Census (INIDE) consisted of polygons in the shape file as well as their alphanumeric information in the sheet format. Some excel macros were created to transfer this information in a way that the alphanumeric text could then be added to the polygons. The results provided more information on our missing communities and a point inside each polygon was created within the GeoDB.
- Phase 10: The information of the Supreme Electoral Council (CSE) was provided in JPG format. In order to extract the location of the missing communities, it was necessary to perform a search over the image, and then generate the georeferencing points by identifying the same points on the Topo-Maps-88. However, this process was aborted, because the land extension of the images was too vast, not allowing to find the pending missing communities.
- Phase 11: Another solution was found based on the request for help from the GIS office staff of the civil defence who knew the fieldwork land. With their help it was possible to review again the list of missing communities, and search for these communities again on the SCE images. Others communities were allocated only using the topographic maps and the known position by the civil defence officers. The communities georeferenced in this way were assigned with the value of “-1”, indicating the possible uncertainty of the point position.

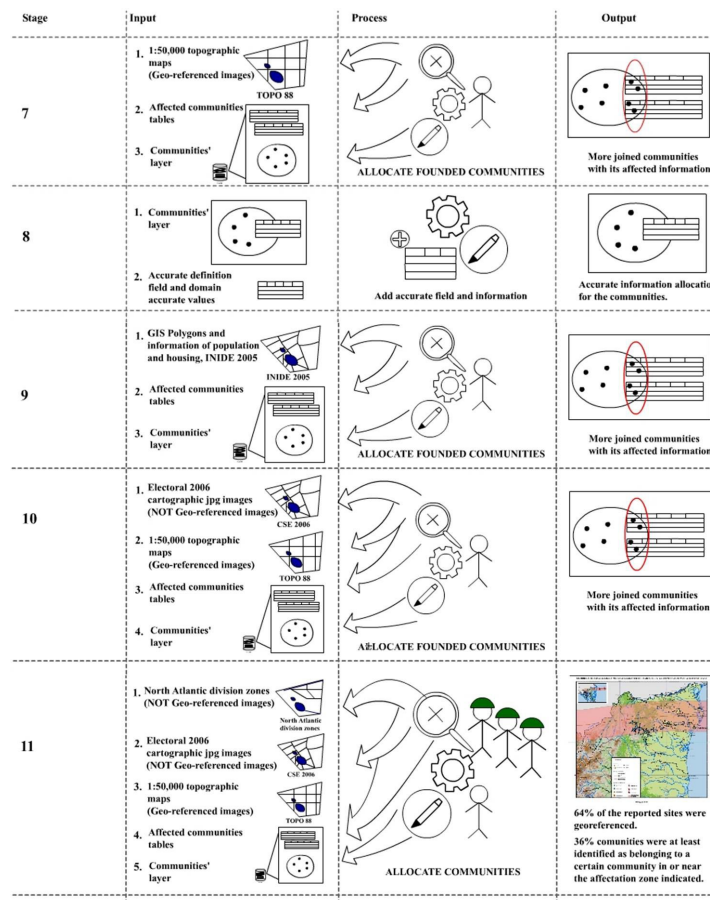


Figure 3. Overview of the georeferencing phases in relation to the workflow process, phases 7 to 11.



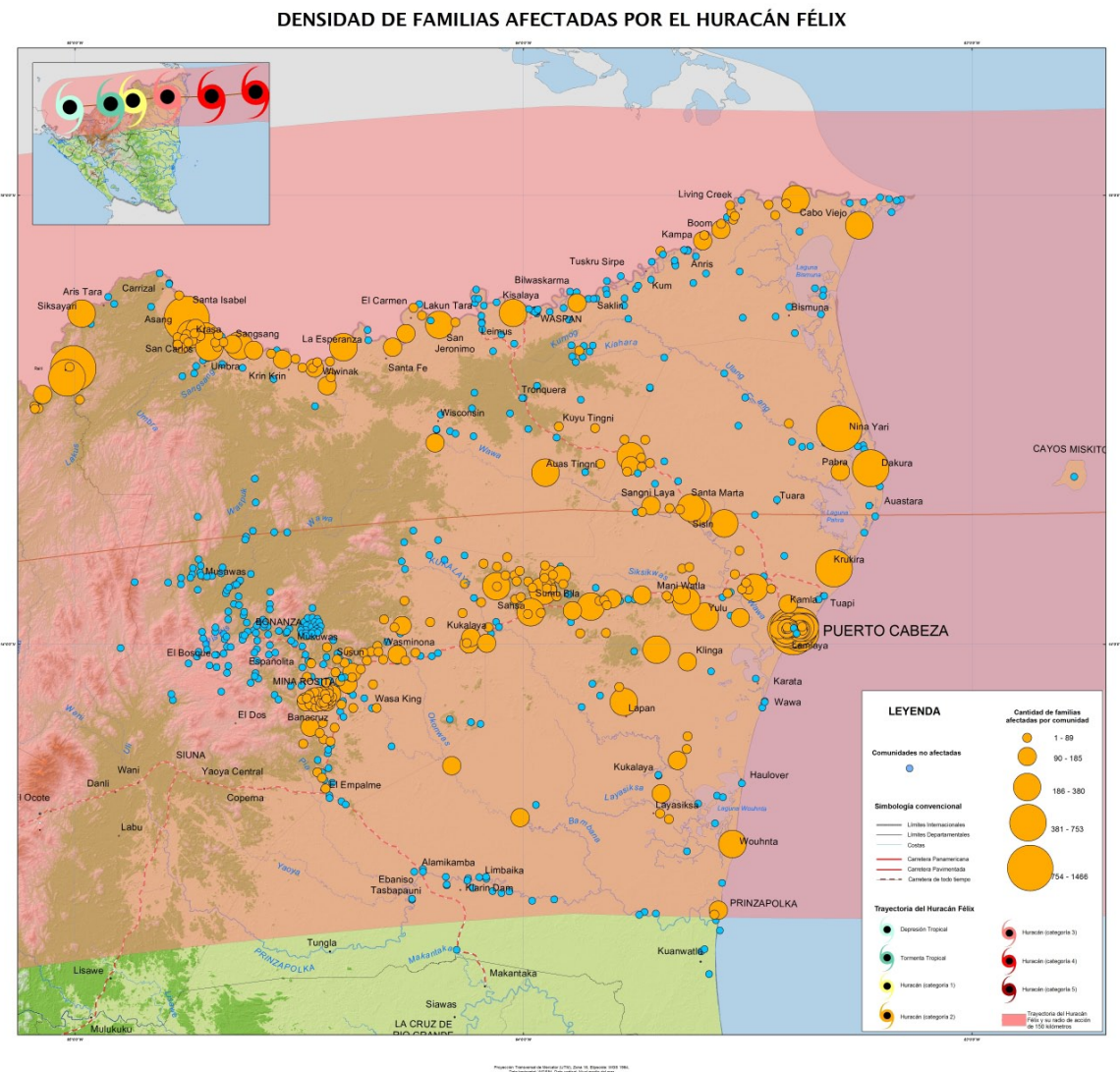


Figure 5. The map of the affected families by community

## CONCLUSIONS

Using an empirical workflow process for mapping the affected communities for the hurricane Felix allowed georeferencing of the most of the communities, the 64% of the reported sites were georeferenced and the remaining 36% were at least identified as belonging to a certain community in or near the affectation zone indicated.

The interviewing of the Nicaraguan Army by their GIS offices made possible to quickly allocate the communities that were missing. They had the necessary field knowledge of the affected communities. The lack of an official channel to exchange geographic information has caused that each Nicaraguan agency to have its own version of the same data, and in other cases, their complementary information was not easily integrated with different agencies.

The proposed workflow process also points out the need to collect information in the field in order to be used in future events for others agencies. But despite of the advances in georeferencing technology, such as mobile devices and GPS technology, some agencies still have limitations to take advantage of them due to their scarce economic resources.

## **REFERENCES**

- 1] [http://www.ineter.gob.ni/Direcciones/meteorologia/Desastres/Huracanes/huracan\\_mitch.htm](http://www.ineter.gob.ni/Direcciones/meteorologia/Desastres/Huracanes/huracan_mitch.htm)
- 2] <http://www.ineter.gob.ni/geofisica/sis/managua72/chavez/isosistas.html>
- 3] <http://www.georiesgos-ca.info>

## **FURTHER READING**

Official Nicaraguan Government information about the total amount of damages caused by the hurricane Felix  
[http://www.redhum.org/archivos/pdf/ID\\_661\\_Redhum-NI-Boletin-Parte\\_extraordinario\\_No.3\\_Huracan\\_Felix-SNAPRED-20070907.pdf](http://www.redhum.org/archivos/pdf/ID_661_Redhum-NI-Boletin-Parte_extraordinario_No.3_Huracan_Felix-SNAPRED-20070907.pdf)

Weather Summary description.

<http://www.ineter.gob.ni/Direcciones/meteorologia/Desastres/Huracan%20Felix/huracan%20felix.html>

List of the Nicaraguan agencies that participated in the hurricane Felix working group.

<http://www.asamblea.gob.ni/opciones/enlaces/gobierno.htm>

The description of the Civil Deference activities.

[http://www.ejercito.mil.ni/defciv\\_03.html](http://www.ejercito.mil.ni/defciv_03.html)