

Application of GIS for hazard and risk assessment: Tegucigalpa, Honduras

Part 5: Flood risk assessment

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This exercise deals with the evaluation of flood risk assessment for a part of Tegucigalpa. We do this by analyzing the areas that are affected by flooding for different return periods (5-years, 10 years, 25 years and 50 years). We also take into account the areas affected by the Mitch flooding and the areas affected by landslides.

Disclaimer

The material in this exercise is for training purposes only. The results should not be used in actual planning of the city of Tegucigalpa as ITC does not guarantee the accuracy and precision of the input data. Due to lack of detailed information, this exercise is very much simplified, and the results will therefore deviate from real values.

The GIS software that will be used in this exercise is the Integrated Land and Water Information System (ILWIS), version 3.11, developed by the International Institute for Geo-Information Science and Earth Observation (ITC). Information: www.itc.nl

Acknowledgements

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5.1 Building and population loss estimation.

Time requirement: 1 hour

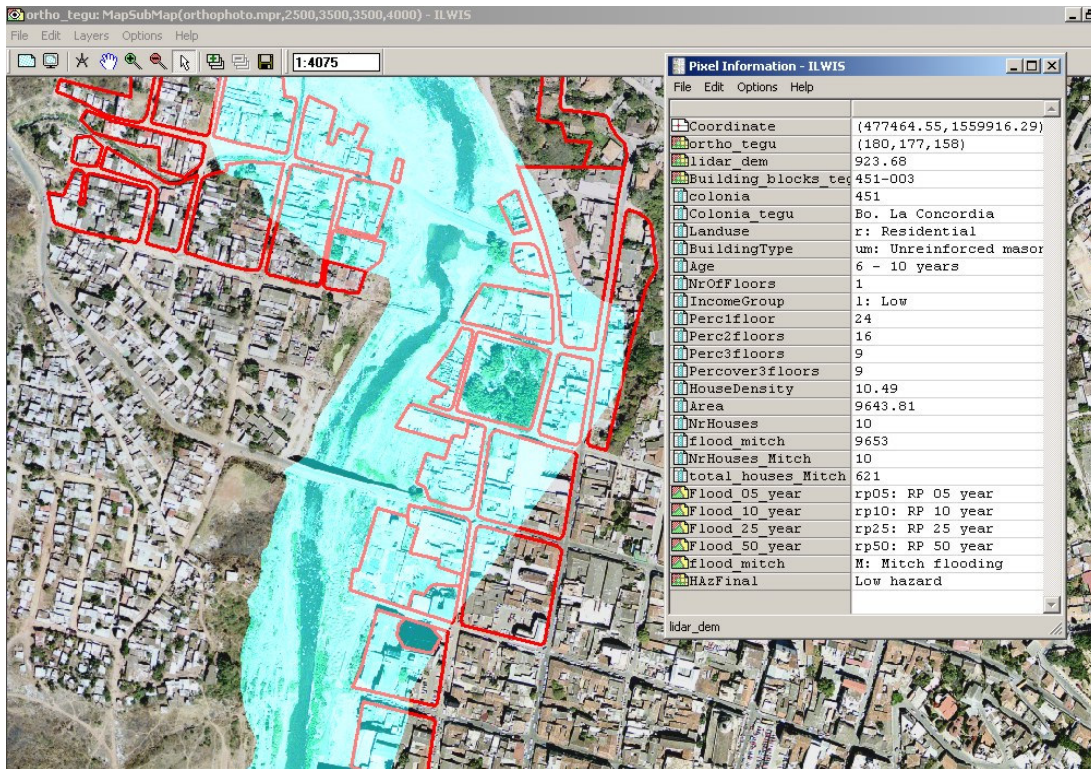
Input data:

- Flood hazard maps for 5 , 10, 25 and 50 years return period. **Flood_05years, Flood_10years, Flood_25years, Flood_50years**, (polygon maps)
- Area affected by Mitch flooding: **Flood_Mitch** (polygon map)
- Landslide susceptibility map : **Hazfinal** (result from previous exercise. Can also be copied from directory results)
- Neighborhoods of the city: **Colonia_tegu** (polygon map and table)
- City blocks in the flood affected area: **Building_blocks_tegu** (maps made in earlier exercise, but can also be copied from directory /results)
- The map **Colonia_tegu** (orthoimage)
- The map **Cross_sections** with cross sections used in the HEC-Ras model for flood hazard assessment.

The first step is to rasterize the various polygon maps.



- Rasterize the polygon maps **Flood_05years, Flood_10years, Flood_25years, Flood_50years, Flood_Mitch, Colonia_tegu and Building_blocks_tegu**. Use the georeference **Tegucigalpa**. Give the raster maps the same names as the polygon maps
- Display the map **Colonia_tegu** (boundaries only with thick red lines) and add the map **Otho_tegu**. Add the polygon maps of the flooding of Mitch. Use transparency of 50 percent. Also add the other flood maps and the landslide map (all with 50 percent transparency). You can select and deselect each layer to see which building blocks are covered.
- Check the results with PixelInfo. See below for an example.



Next we would like to know the average population density for the city blocks located in flood affected areas. Unfortunately we only have this information at the colonia level, so we will have to generalize.



- Calculate the histogram for the raster map **Colonia_tegu**.
- Open the attribute table **Colonia_tegu** and select Columns / Join. Join with the histogram **Colonia_tegu**, and read in the **Area** in the table.
- Now calculate the average Number of houses per hectare (1 hectare = 100 * 100 meters). Type on the command line of the table window:
HouseDensity:=10000*(houseNr/Area)
- And calculate the average number of people per house:
Personsperhouse:=population/housenr
- As you can see the database contains some errors. We will use 4.95 persons per house in average
- Calculate the histogram of the map **Building_Blocks_tegu**
- Open the attribute table **Building_Blocks_tegu** and select Columns / Join. Join with the histogram **Building_Blocks_tegu**, and read in the **Area** in the table.
- Select Columns / Join and select the table **Colonia_tegu**. Read in the column **Housedensity**
- Calculate the number of houses per building block using the following formula:
NrHouses:= (Area/10000)*housedensity.
Use value range from 0 to 100 and precision of 1
- Display the map **Ortho_tegu** and add the polygon map **Building_block_tegu**. Select transparency 50 Percent, and select attribute **NrHouses** (display with psuedo colour from 0 to 50)

- Check the result in the map.

As you can see this information is not very reliable. If you have made the building inventory fieldwork in exercise 2 it would be better to use that information.

We will now calculate how much percentage of each block was affected by flooding during Mitch.

- Cross the map **Building_blocks_tegu** with the map **Flood_Mitch**. Name the output table **Flood_mitch**
- Open the attribute table **Building_blocks_tegu** and join with the cross table **Flood_mitch**. Read in the column Area, and name it **Flood_Mitch_area**.
- Calculate the Number of houses affected during Mitch using the following formula:

$$\text{NrHouses_Mitch} := \text{iff}(\text{isundef}(\text{flood_Mitch_area}), 0, (\text{Flood_Mitch_area}/\text{Area}) * \text{NrHouses})$$
 - The results shows the number of houses affected during the Mitch flooding
 - Calculate the total number of houses affected by Mitch by summing up all houses. Select *Columns / Aggregate* select the column **NrHouses_Mitch** and the function SUM. Don't group by. Name output column **Mitch_total**.
 - Write down the results in the table below.

	Nr of Houses	Houses with 1 floor	Houses with 2 floors	Houses with 3 floors	Houses with more than 3 floors	People affected
Mitch						
5 – year flooding						
10 year flooding						
25 – year flooding						
50 – year flooding						
Landslides						

We have calculated earlier also the percentage of building with 1 floor, 2 floors, 3 floors and more than 3 floors. We can use that information now also to calculate the number of single story buildings affected. We do that first for the Mitch event.

- In the table **Building_blocks_tegu**, make the following calculation:

$$\text{Nr1story_houses_Mitch} := (\text{Perc1floor}/100) * \text{NrHouses_Mitch}$$
 - Calculate the total number of 1 floor houses affected by Mitch by summing up all houses. Select *Columns / Aggregate* select the column **Nr1story_houses_Mitch** and the function SUM. Don't group by. Name output column **Nr1story_houses_Mitch_total**.
 - Write down the results in the table
 - Repeat this for the houses with 2 floors and 3 floors. Also write the results in the table

We can also calculate the number of people affected per building block.



- In the table Building_blocks_tegu, make the following calculation:
Nrpeople_Mitch:= 4.95* NrHouses_Mitch
- Calculate the total number of 1 floor houses affected by Mitch by summing up all houses. Select *Columns / Aggregate* select the column **Nrpeople_Mitch** and the function SUM. Don't group by. Name output column **Nrpeople_Mitch_total**.
- Write down the results in the table

The same procedure can be followed for the flood events with return periods of 5, 10 25 and 50 years, and also for the area covered by high landslide hazard.



- Calculate the number of houses affected and the number of people affected for the various flood events and for the high landslide hazards.
- Write down all the results in the table
- Make plots of return period against potential damage.

If you have collected better information for the building blocks during the fieldcollection, it would be much better to use that.

Relation with water height

Water-surface elevations for an estimated 50-year -flood on Río Choluteca, Río Grande, Río Guacerique, and Río Chiquito at Tegucigalpa were determined using HEC-RAS, a one-dimensional, steady-flow, step-backwater computer program. The channel and floodplain cross sections used in HECRAS were developed from an airborne light-detection and-ranging (LIDAR) topographic survey of the area and ground surveys at bridges. There are no nearby long-term stream-gaging stations; therefore, the 50-year-flood discharges were estimated using a regression equation that relates the 50-year-flood discharge to drainage area and mean annual precipitation. The estimated 50-year-flood discharge is 922 cubic meters per second at Río Choluteca at downstream end of the study area boundary, 663 cubic meters per second at the mouth of the Río Grande, 475 cubic meters per second at the mouth of the Río Guacerique, and 254 cubic meters per second at the mouth of the Río Chiquito. (From Mastin and Olsen (USGS))

An overview of the cross sections is given in the figure below.

The objective of this exercise is to calculate the flood surface level, based on the results from the HEC-RAS modelling, and to compare the information with the building height.

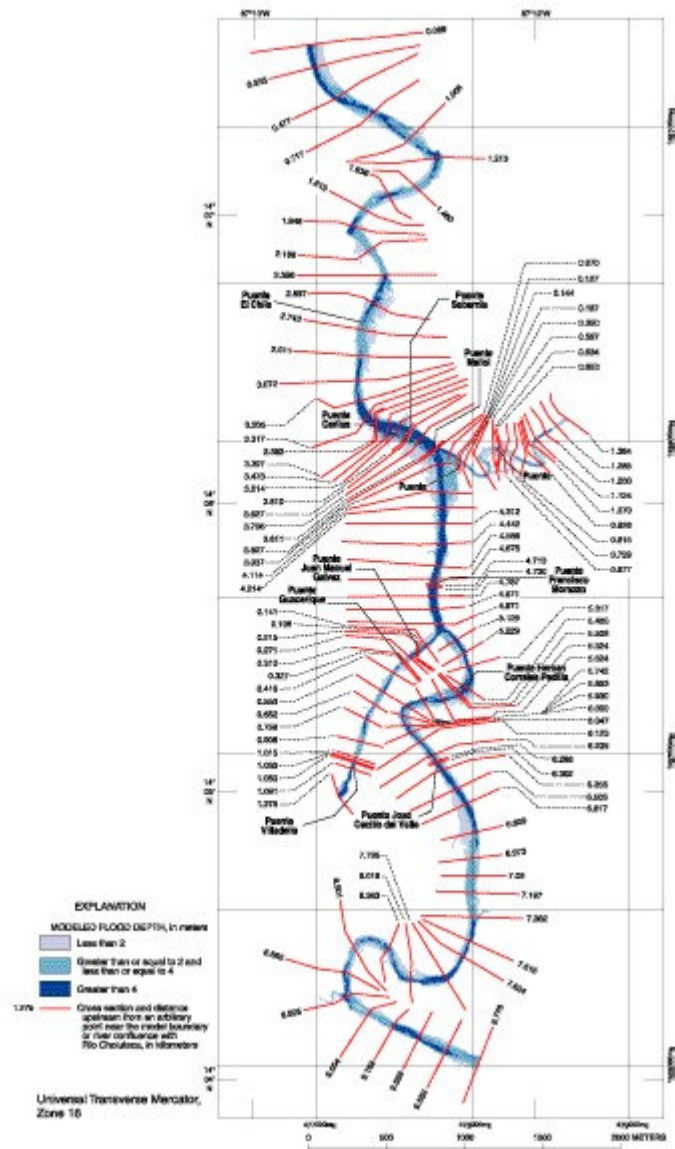


Figure: cross sections used in the hydrological modelling by the USGS.

- Open the raster map **ortho_tegu** and overlay the cross section on it (segment map **Cross_sections**, with line thickness of 3). Make sure Info is selected in the Display options
- Check the related attribute information of the cross_sections.

One of the attributes is related to the waterheight. We will make an attribute map of it and interpolate the waterheights.

- Select *Operations / Vector Operations / Segments / Attribute Map*. Select the map **Cross_sections**, the Column **WaterHeight**, and name

the output map **WaterHeight**.

- Select *Operations / Interpolation / Contour Interpolation*. Select the segment map **WaterHeight**, the Georeference **Tegucigalpa** and the output map **Waterheight**.

The flooded area can be calculated by comparing the map with the Digital Elevation Model.



- Type the following formula on the command line of the main window:
Height_of_water:=iff(waterheight>Lidar_dem, waterheight - Lidar_dem, 0)
- Cross the map **Building_blocks_tegu** with the map **Height_of_water**.
- Calculate the average water height in the building blocks and relate it with the number of floors.

References

- Mark C. Mastin and Theresa D. Olsen
Fifty-Year Flood-Inundation Maps for Tegucigalpa, Honduras. Water-Resources Investigations Report 02-261 U.S. GEOLOGICAL SURVEY