Development of a GIS Application for seismic vulnerability and earthquake damage studies in Nicaragua

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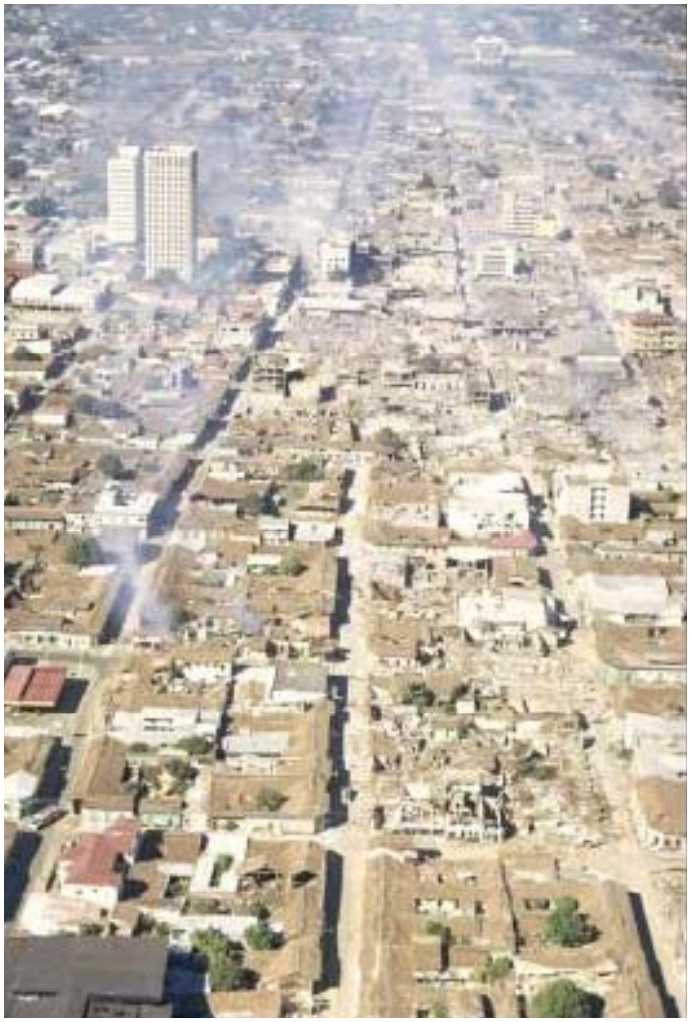
INETER/Managua, Nicaragua



Damages of the 1972 Managua Earthquake

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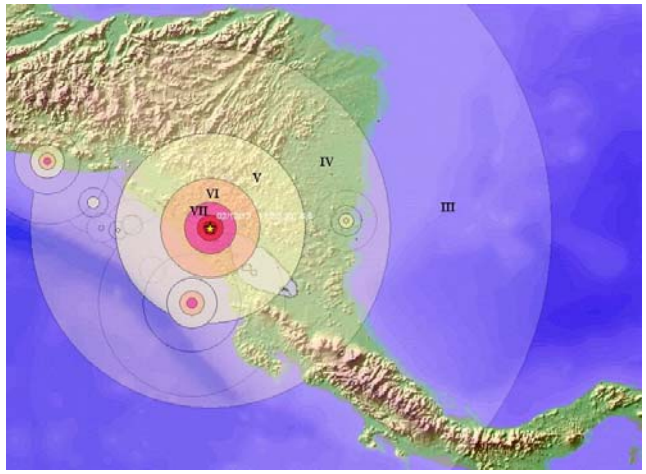
1. Introduction
2. Objective of the application
3. Disadvantage of the traditional way of work
4. New application “VULNESIS”
   - functionalities and its way of work

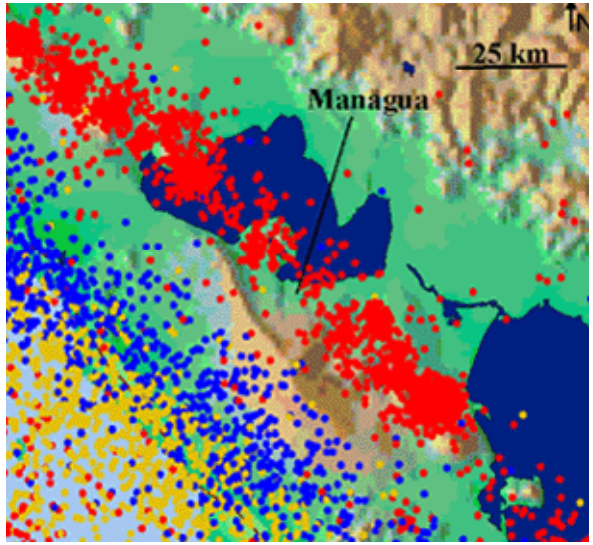
1. INTRODUCTION

Nicaragua is a country with a high seismic activity. Earthquakes have been provoking thousands of deaths and infrastructure destruction. The economic losses and socio-cultural damages complicate the development of the country.

In order to contribute to the prevention and risk mitigation, seismic vulnerability and risk studies have been carried out, in recent years, by several scientific groups applying different methodologies.



Isoseisms of a simulated Earthquake in Managua and its effects in C.A



Managua seismicity

2. OBJECTIVES OF THE DEVELOPMENT OF THE APPLICATION

1. Provide to INETER, Nicaraguan Universities and other institutions with a software tool that implements all the requirements related to earthquake and damage studies.

2. Considering the specific methodology of the seismic vulnerability index.

3. Reducing time and efforts for the accomplishment of seismic vulnerability studies.

What means seismic vulnerability study for a town

- It is to determine the probable response of buildings to the impact of possible seismic events

To do this-

- … to identify the construction parameters of all the buildings.
- … but, it cannot be done in a detailed way for all buildings, due to time and cost limitations.
- … for all houses we have the data of the municipal cadastre which contain certain interesting information for our purposes.
- … grouping the houses in construction types according certain parameters (adobe, concrete, …, single floor, two-floors…, type of roof)
- … the randomly selecting a number of houses for each group, visiting them and their vulnerability determination.
- … from the mean value of the vulnerability of the visited houses we get a vulnerability index for each group of buildings.
- … this index is applied to all houses of the group.
- … at the end we get an estimate of vulnerability fore each house in the cadastre data base.
- Finally We can plot a map of the vulnerability to investigate the spatial distribution.

Types of houses, Leon City, Nicaragua

Adobe, 1 store, before 1972

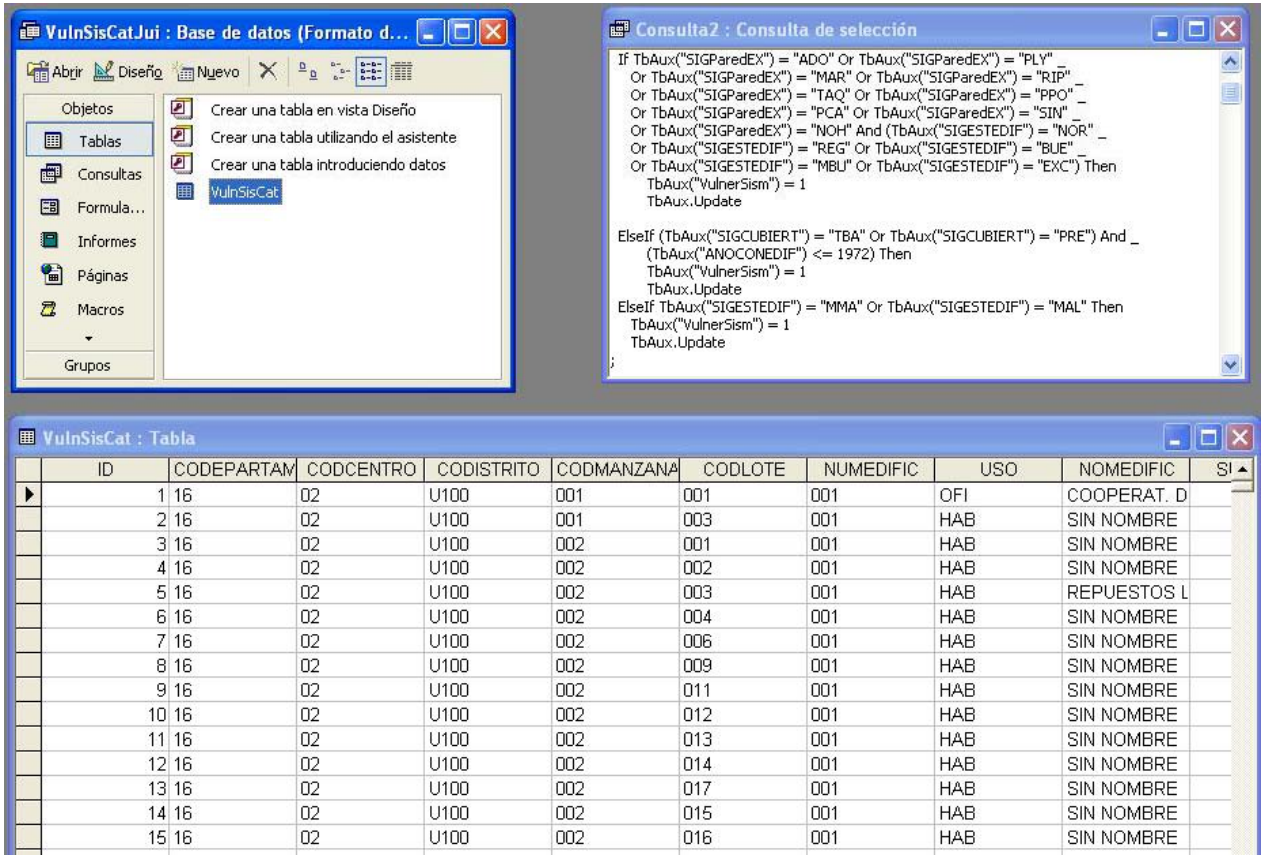
Concrete, 2 stores, after 1972

3. DISADVANTAGE OF THE TRADITIONAL WAY OF WORK

In Nicaragua, the assessment of seismic vulnerability was carried of distinct tasks, as:

* Obtaining database from municipal cadastre.
* Grouping the houses according typologies. Software tool: MS ACCESS.
* For each typology - Selecting a percentage of houses to be visited for getting data for the calculation of their vulnerability index.

Software Tool: None (this step was done manually)



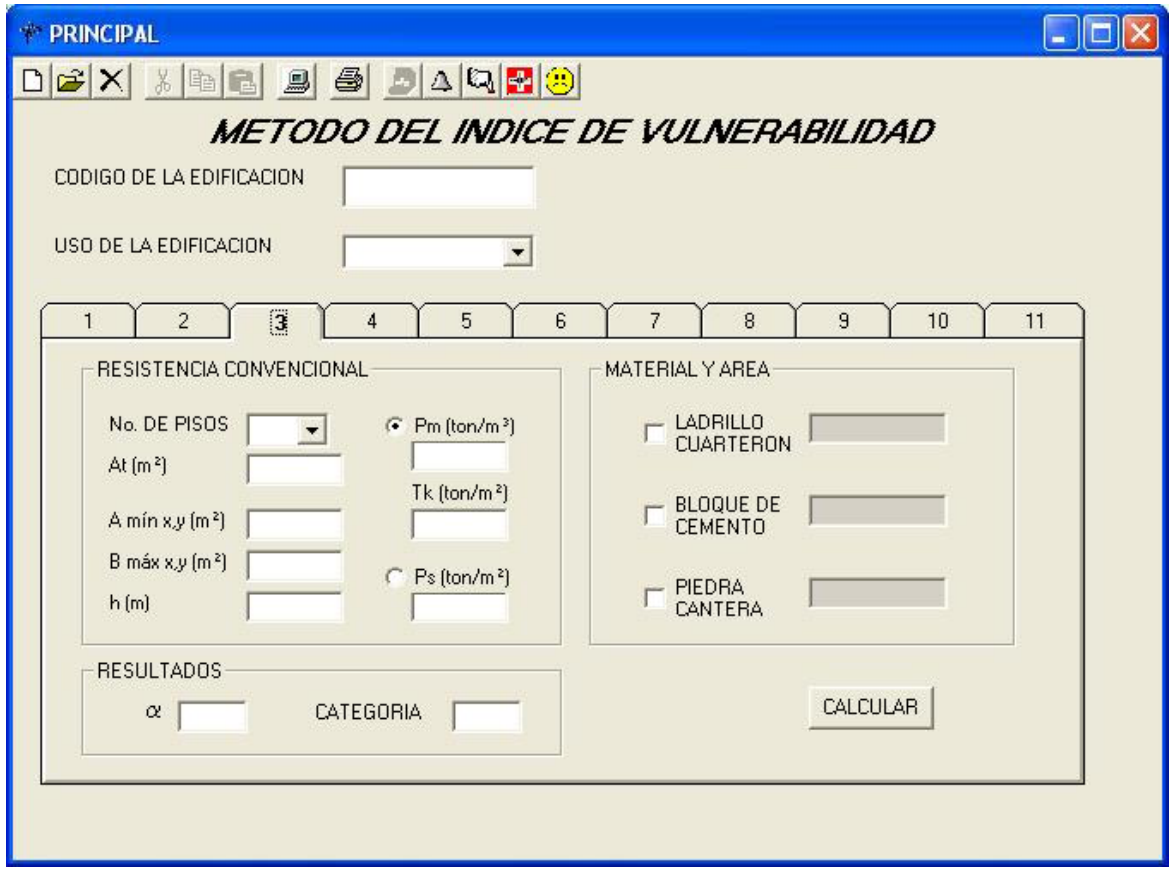
ID	CODEPARTAM	CODCENTRO	CODISTRITO	CODMANZANA	CODLOTE	NUMEDIFIC	USO	NOMEDIFIC
1	16	02	U100	001	001	001	OFI	COOPERAT. D
2	16	02	U100	001	003	001	HAB	SIN NOMBRE
3	16	02	U100	002	001	001	HAB	SIN NOMBRE
4	16	02	U100	002	002	001	HAB	SIN NOMBRE
5	16	02	U100	002	003	001	HAB	REPUESTOS L
6	16	02	U100	002	004	001	HAB	SIN NOMBRE
7	16	02	U100	002	006	001	HAB	SIN NOMBRE
8	16	02	U100	002	009	001	HAB	SIN NOMBRE
9	16	02	U100	002	011	001	HAB	SIN NOMBRE
10	16	02	U100	002	012	001	HAB	SIN NOMBRE
11	16	02	U100	002	013	001	HAB	SIN NOMBRE
12	16	02	U100	002	014	001	HAB	SIN NOMBRE
13	16	02	U100	002	017	001	HAB	SIN NOMBRE
14	16	02	U100	002	015	001	HAB	SIN NOMBRE
15	16	02	U100	002	016	001	HAB	SIN NOMBRE

3. DISADVANTAGE OF THE TRADITIONAL WAY OF WORK

* Calculation of vulnerability index for each selected house.

Software Tools:

1) Raven 2002
2) Ms - Excel



* Calculation of damages for earthquakes scenarios

Software Tools:

1) Raven 2002
2) Ms - Excel

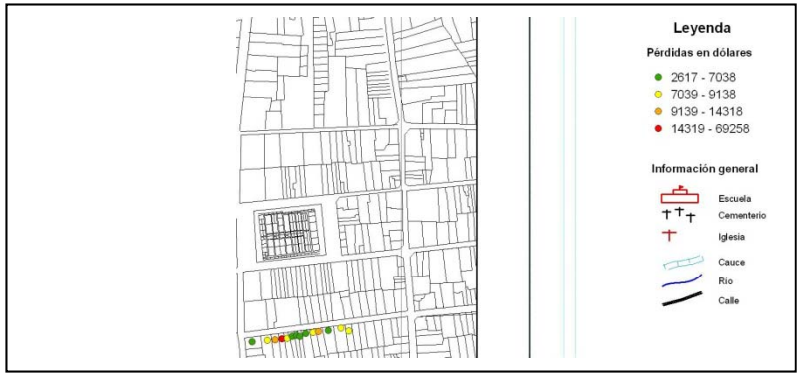
Excel is used for saving the calculation of each house because raven doesn't work with Data Bases, it doesn't have memory, it is just like a calculator.

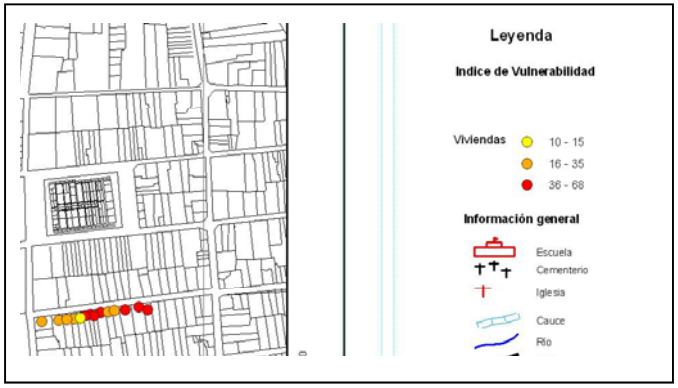
3. DISADVANTAGE OF THE TRADITIONAL WAY OF WORK

* Placing all the transformed data in a correct format for to be imported to the GIS, for its presentation on maps. Software tool: ms - excel

IV	IVNOR	Niv_IV	ID1	Niv_ID1	ID2	Niv_ID2	ID3	Niv_ID3	ID4	Niv_ID4	X	Y
91.25	23.86	MEDIA	0.1759	Menor	0.4141	Severo	0.7716	Severo	1.0694	Total	-86.2974629352	12.1528110906
72.50	18.95	MEDIA	0.1549	Menor	0.3746	Moderado	0.7042	Severo	0.9788	Total	-86.2979985097	12.1530195506
77.50	20.26	MEDIA	0.1603	Menor	0.3843	Moderado	0.7201	Severo	1.0000	Total	-86.2980051479	12.1528317177
91.25	23.86	MEDIA	0.1759	Menor	0.4141	Severo	0.7716	Severo	1.0694	Total	-86.2980009298	12.1529376428
146.25	38.24	ALTA	0.2445	Menor	0.5436	Severo	0.9922	Total	1.3660	Total	-86.2979007019	12.1529903394
40.00	10.46	BAJA	0.1201	Menor	0.3142	Moderado	0.6053	Severo	0.8479	Total	-86.2978215523	12.1529882377

* Layouts creation for the presentation of the vulnerability and damages results in several displaying way: houses, blocks and one layout for each damage scenario. Software tool: ArcGIS - ESRI





The creation of spatial-relationships for presenting the resulting vulnerability and damages estimations over a map is always needed.

4. THE NEW APPLICATION "VULNESIS" - FUNCTIONALITIES AND ITS WAY OF WORK

The analysis the previous working way allows us to decide the developing the new software for the assessment of the vulnerability and damages due to earthquakes within the environment of a Geographical Information System (GIS)::

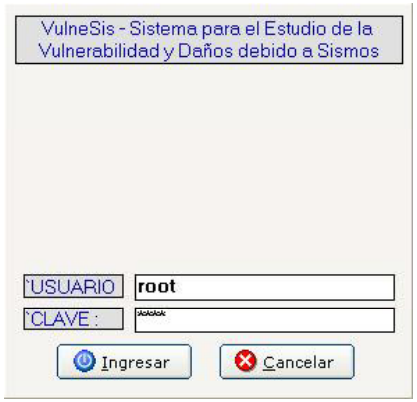
General steps integrated in the new software :

1) The support the automatic and interactive grouping of houses in typologies using the municipal cadastre data
2) Automatically and randomly selection of a number of houses spatially distributed for each typology house; houses which will be visited to determine its vulnerability index.
3) Applying the specific methodologies of seismic vulnerability index.
4) Calculation of damages (Scenario) using the vulnerability index.
5) Presenting the results over maps at any stage of the work..

With this integrated software system the user has not to care about separated software tools for each part of the studio process, also avoiding translate data for one software to other..

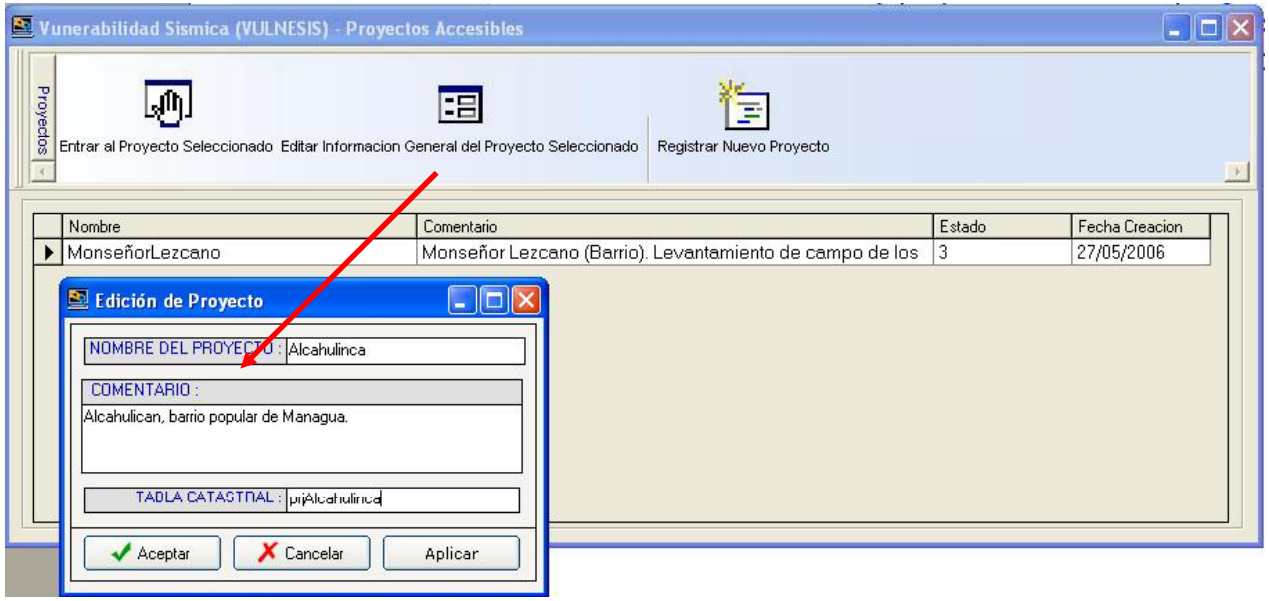
4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

Login into the system:



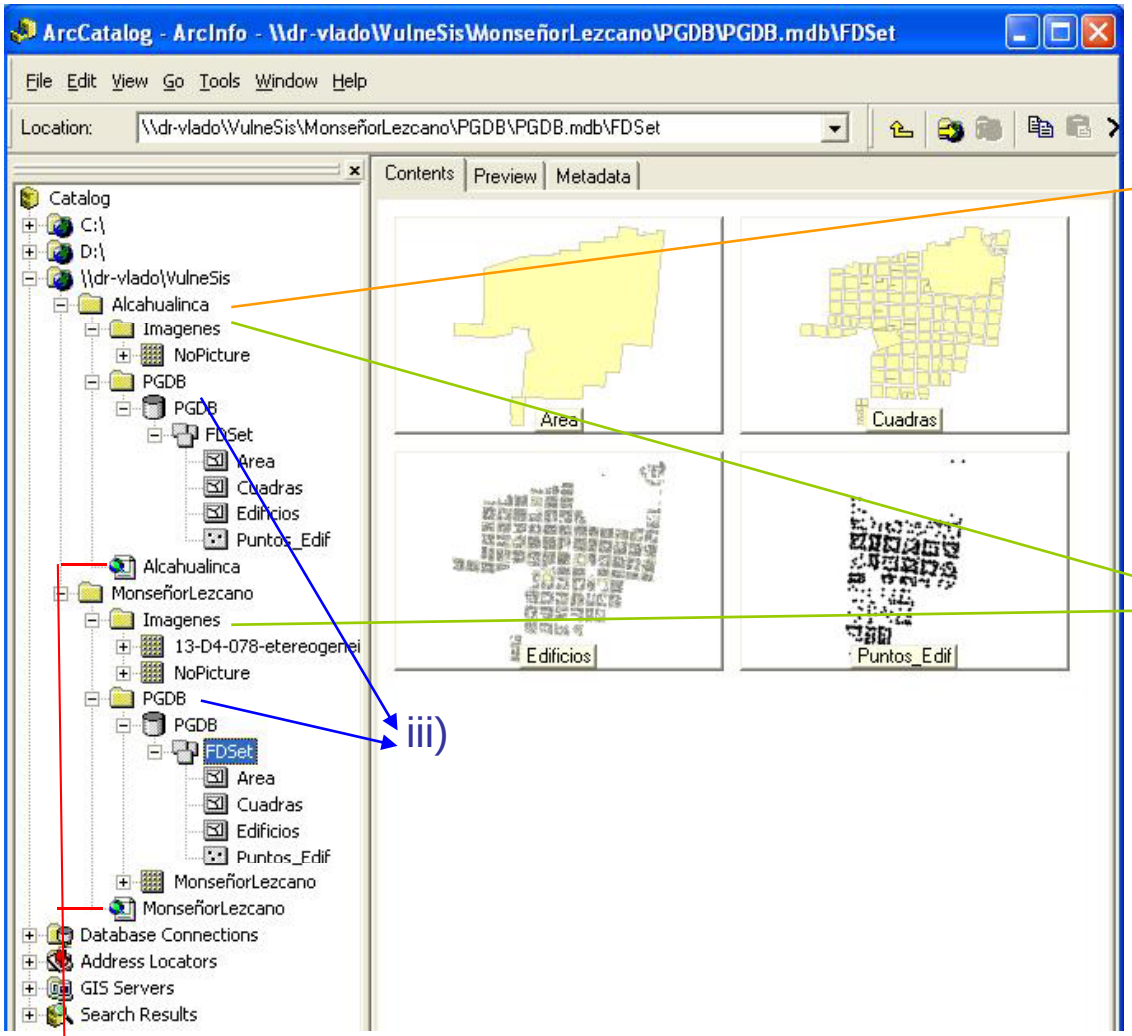
Login Window

Creation of a new project:



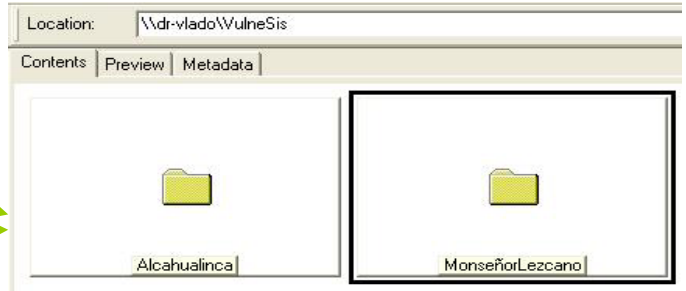
Grid with a list of all vulnerability projects, and dialog for the new project creation

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



Step 1) Creating of the specific for the new project

i)



ii)

iii)

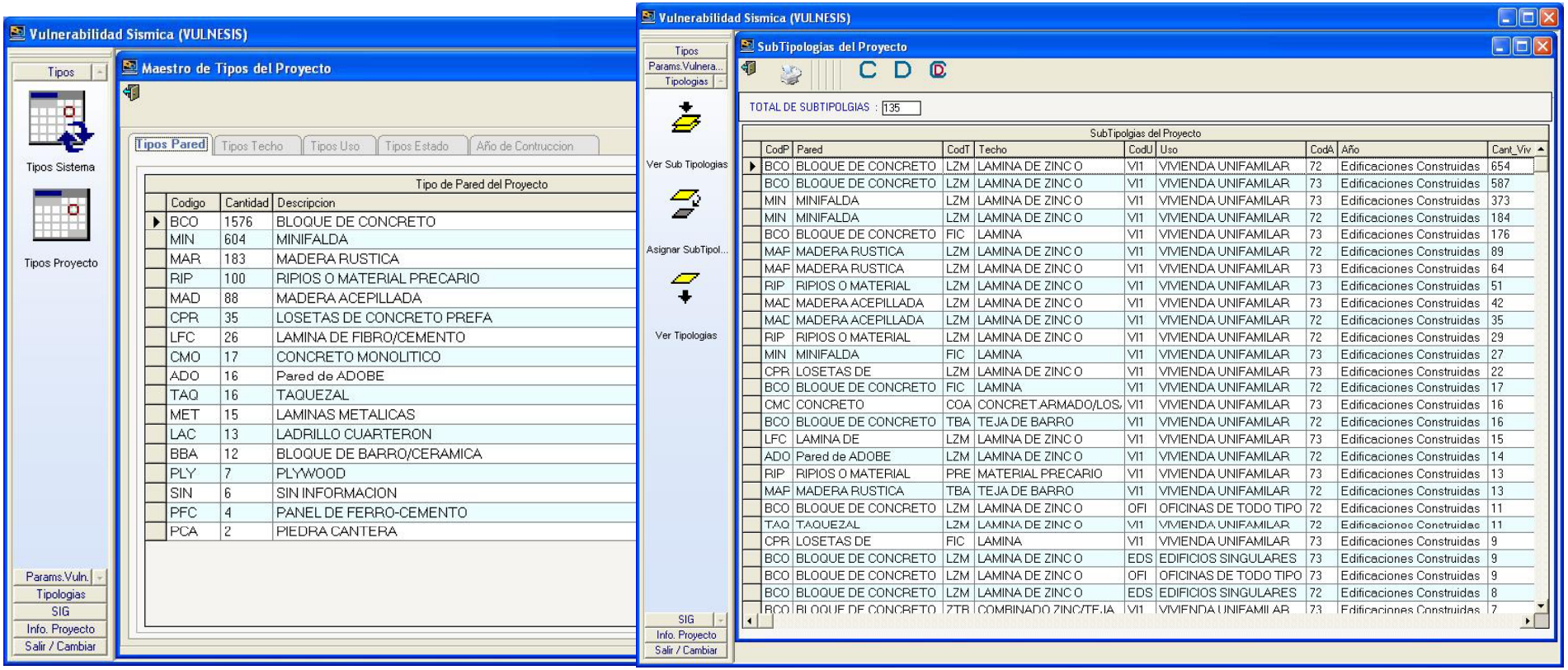
iv) And also the app creates a Map file that hold the layout.

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

STEP 2: The software start the automatic grouping houses in sub typologies using the municipal cadastre data.

This step is made in order to find in the cadastre data for the specific project all the variations of wall, roof, type of use, constructed before or after 1973, these variations are know as SubTypologies.

The houses are marked for to indicate the SubTypology that they are part.



4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

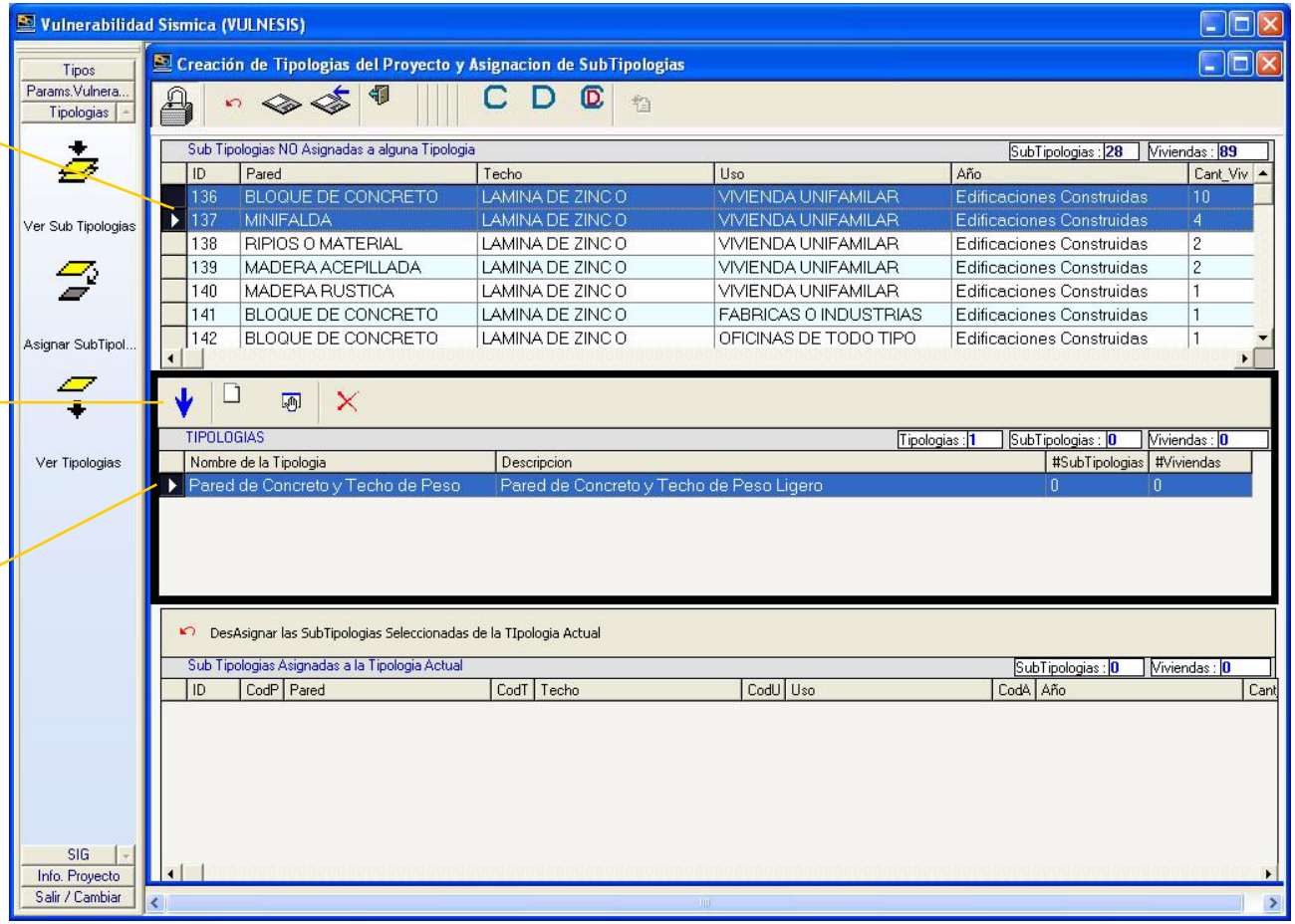
Then SubTypologies are grouped interactively in more general classifications called Typologies, this classification is commonly knowing for specialists.

SubTypologies are usefully for to know the real type of houses variation and for avoid to clasify house by house into a major typology, for example it is easily group 135 SubTypologies into 10 Typologies than 2700 houses into the same10 typologies.

ii) Selected the SubTypologies that will be assigned to a general typology

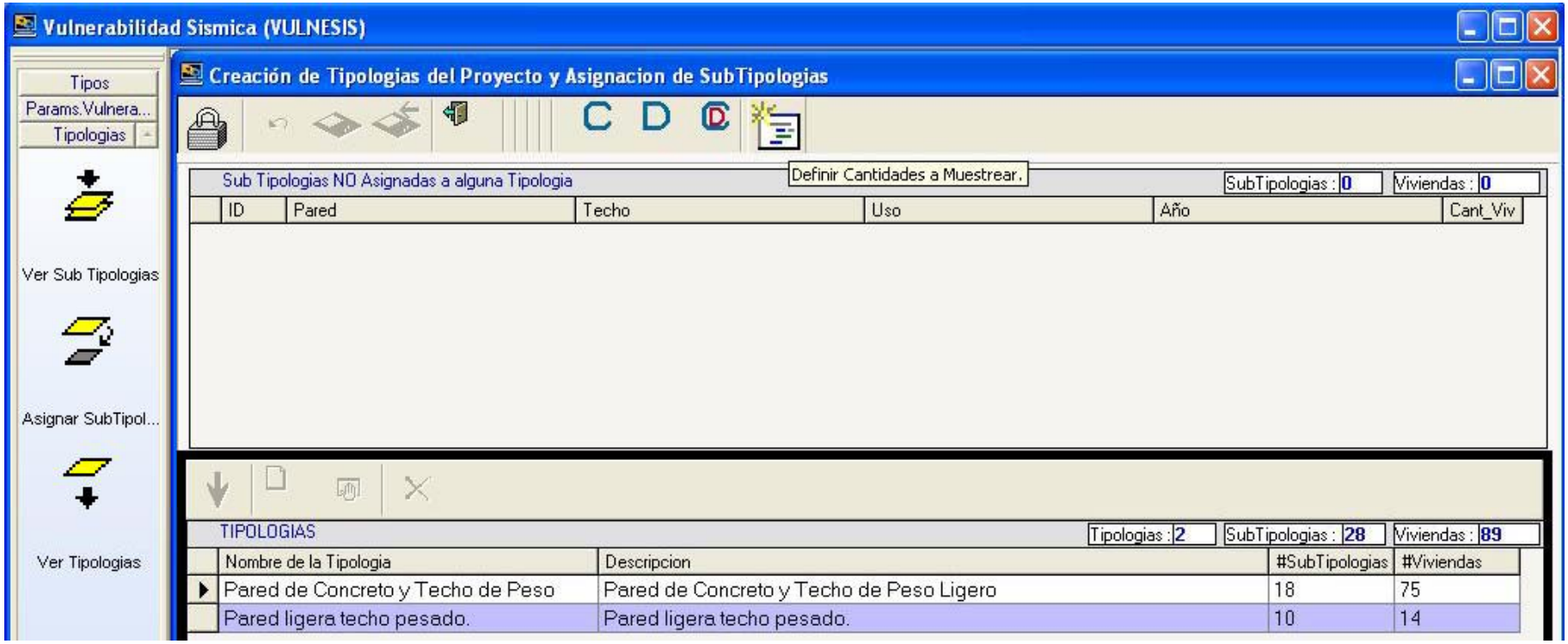
iii) … the command that assign the select SubTypologies into the selected Typology.

i) General typology: The major way of houses grouping.

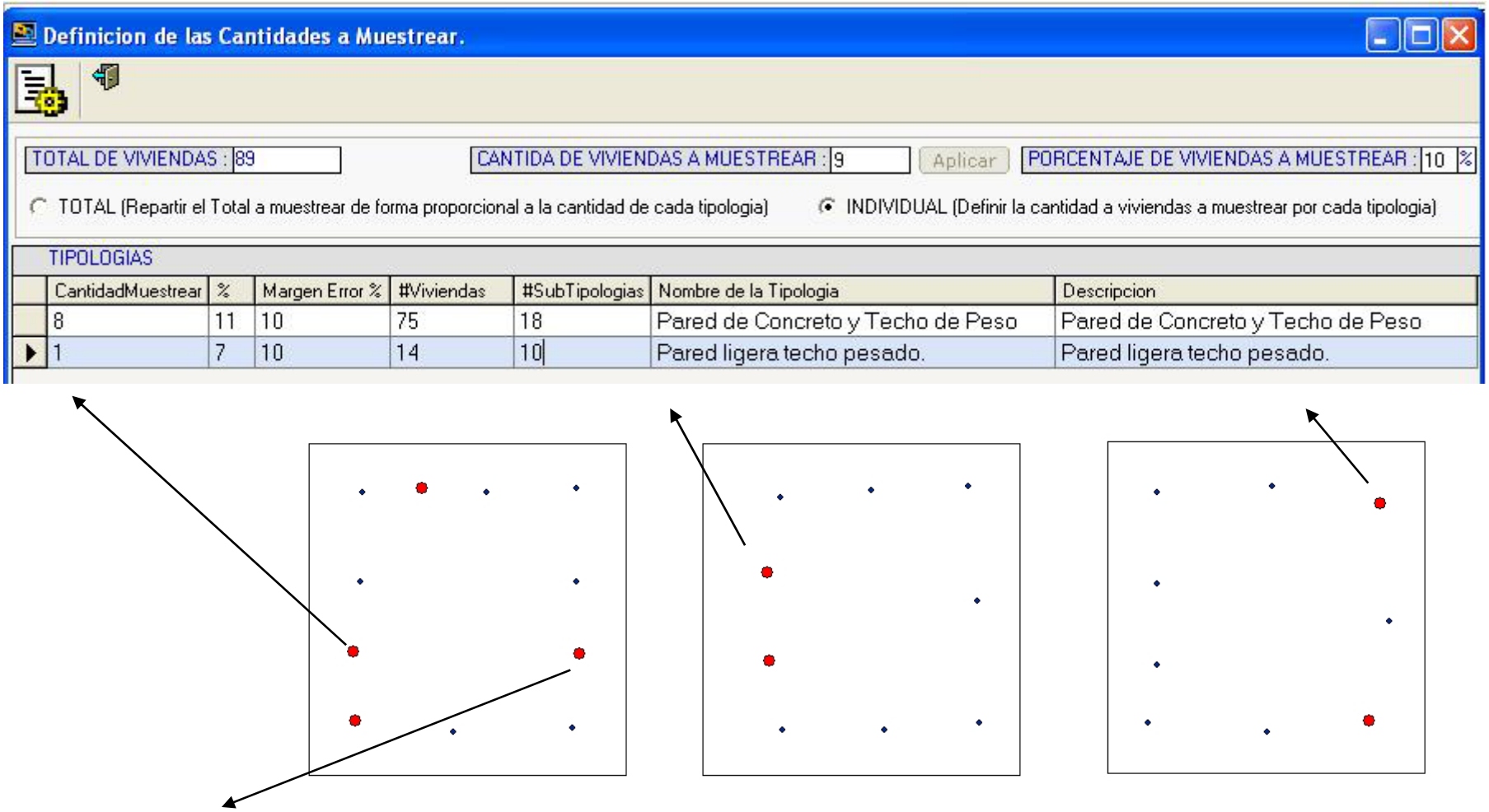


4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

When all the subtypologies are assigned to general typologies, or in other words when all the houses are grouped into general typologies then the software allows to define the number of houses that will be selected for to be visited to collect its vulnerability information that the software will calculate.



… then the software define the number of houses for each typology that will be randomly and spatially distributed selected:



4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

After the selection of the houses the software presents its reports with the format that will be used for fill in the vulnerability information over the field.

ViviendaID : 2726 Codigo Catastral: 10 – 03 – J206 – 005 – 004 – 001 Observador : _____

Fecha (dd/mm/aa) : _____ Dirección : _____

1. Organización del sistema resistente : ____	2. Calidad del sistema resistente :____
3. Resistencia convencional : 1. Número de pisos N : ____ 2. Area Total Cubierta At : _____ · ____ m2 3. Area resistente sentido x Ax : _____ · ____ m2 sentido y Ay : _____ · ____ m2 1. Resistente cortante mampostería tk : _____ · ____ Ton / m2 2. Altura media de los pisos h : ____ · ____ m 3. Peso específico mampostería Pm : _____ · ____ Ton / m3 4. Peso por unidad de área diafragma Ps : _____ · ____ Ton / m2	4. Posición del edificio y la simentación : ____ 5. Diafragmas horizontales : ____ 6. Configuracióon en planta b1 = a/L : ____ / ____ b2 = b/L : ____ / ____ 7. Configuracióon en eleva T / H % : ____ / ____
8. Distancia máxima entre los muros L / S : _____ / _____	9. Tipo de cubierta : ____
10. Elementos no estructurales : ____	10. Estado de conservació

ViviendaID : 2727 Codigo Catastral: 10 – 03 – J206 – 003 – 012 – 001 Observador : _

Fecha (dd/mm/aa) : _____ Dirección : _____

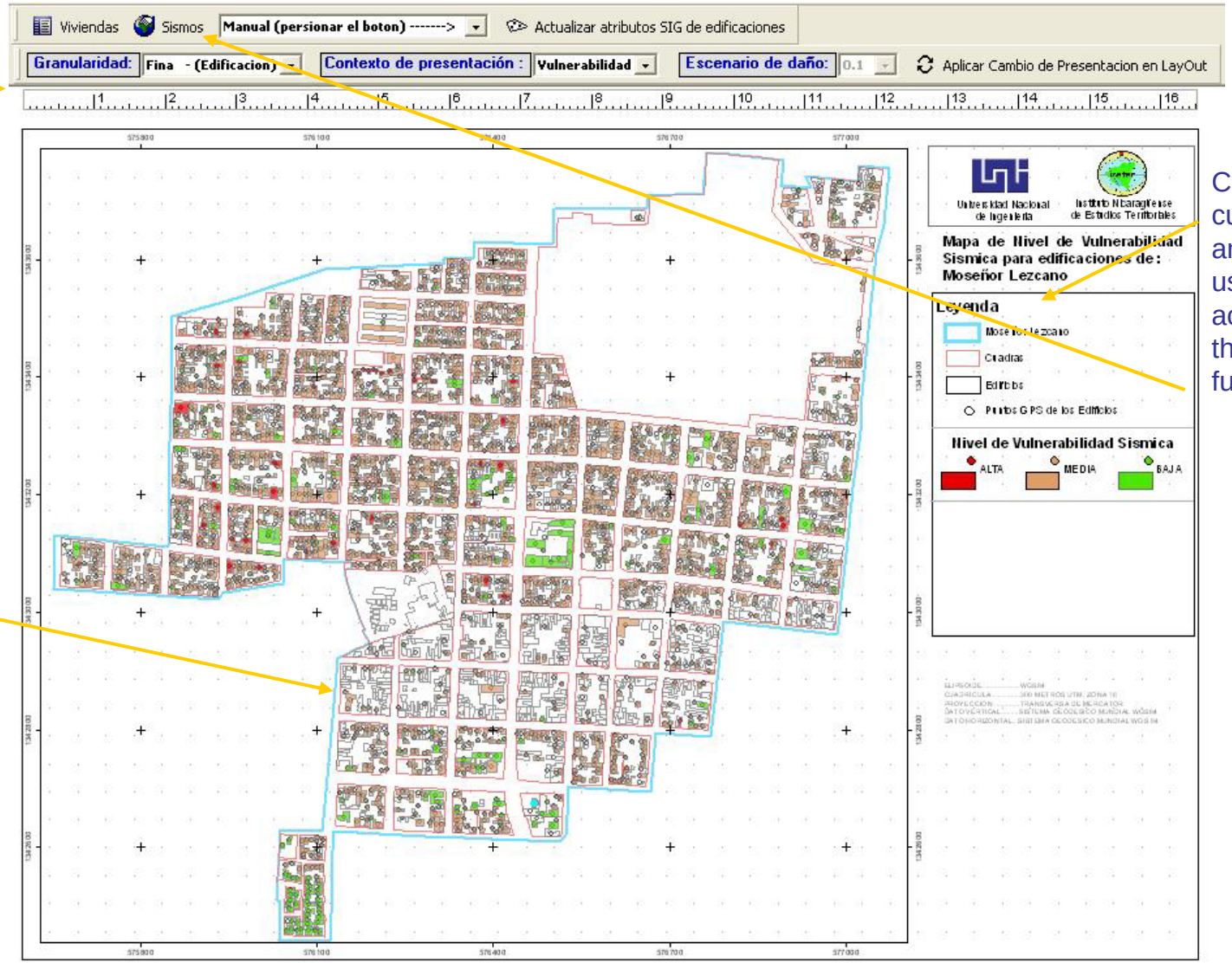
1. Organización del sistema resistente : ____	2. Calidad del sistema res
3. Resistencia convencional :	

TODAS LAS VIVIENDAS

DEPARTAM	CENTRO	DISTRITO	MANZANA	LOTE	EDIFIC	YA	Foto_ID	flagIV	ViviendaID	Nombre Tipologia
10	03	U206	003	001	001				151	Tipologia2
10	03	U206	003	002	001			True	8	Tipologia1
10	03	U206	003	003	001			True	77	Tipologia1
10	03	U206	003	004	001				11	Tipologia4
10	03	U206	003	005	001				63	Tipologia2
10	03	U206	003	006	001			True	35	Tipologia2
10	03	U206	003	007	001			True	59	Tipologia3
10	03	U206	003	008	001				10	Tipologia2
10	03	U206	003	009	001				83	Tipologia2
10	03	U206	003	010	001				96	Tipologia2
10	03	U206	003	011	001				85	Tipologia4
10	03	U206	003	012	001			True	7	Tipologia4
10	03	U206	004	002	001			True	55	Tipologia5
10	03	U206	004	003	001				1	Tipologia3
10	03	U206	004	004	001			True	22	Tipologia1
10	03	U206	004	004	002				44	Tipologia1
10	03	U206	004	004	003				16	Tipologia2
10	03	U206	004	005	001				64	Tipologia2
10	03	U206	004	006	001				153	Tipologia3
10	03	U206	004	007	001				42	Tipologia2
10	03	U206	004	008	001				9	Tipologia4

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

Programmed GIS extensions (VulneSIs) in Visual Basic program language whit ArcObjects and Sql-Server like RDMBS (Relational Database Managed system)



Context of the current project and user (some user have not access to all the functionalities

Geographical layer of the current project, Area, Blocks and Parcels, but the app can work without these, it can work with only the points taken for the data field collection work

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

The "Viviendas" Button display a dialog (next image) for the selection and finding of houses, depends of certain parameters of search. Also the user can mix between several parameters or don't use parameters -> (all houses are showing)

Parameters of houses searching

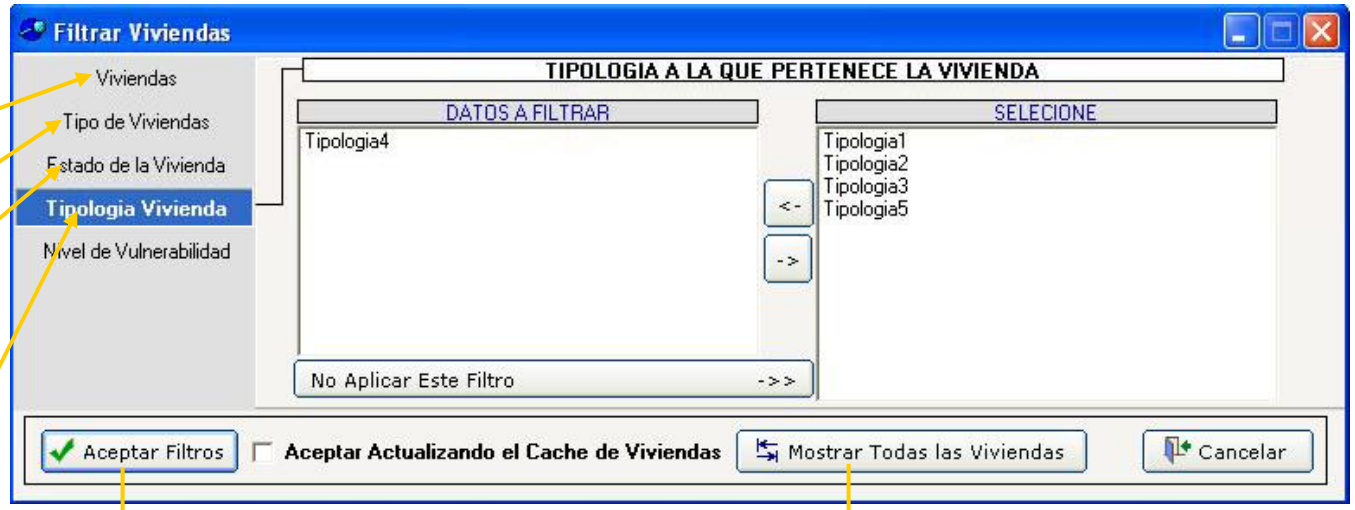
1) Intervals of houses Ids.

2) Houses selected for the vulnerability work field.

3) Edited or not edited houses.

4) Houses members of certain typologies.

5) Houses that had certain vulnerably levels.

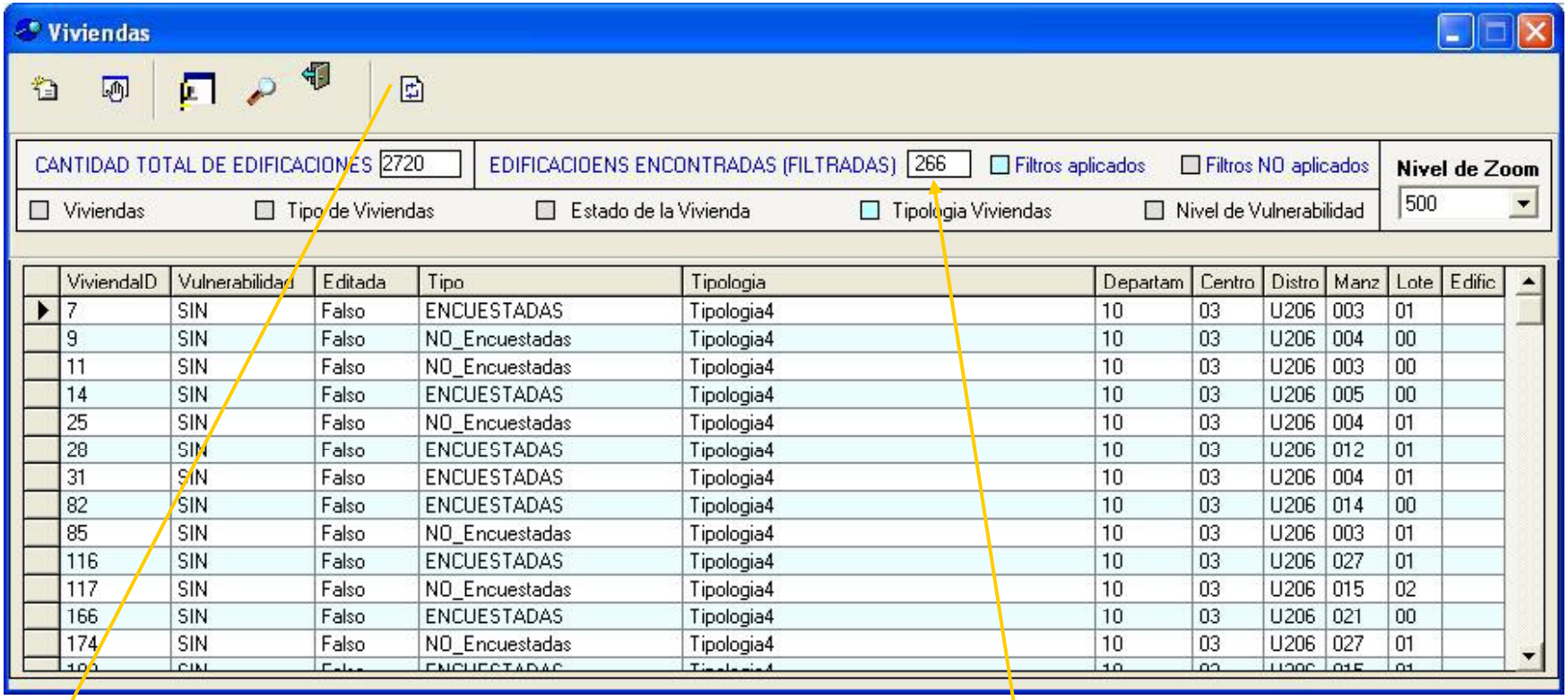


This option show all the houses without apply any parameter.

After clicking the "Aceptar" (Accepted button) are presented the houses who have true for the selected parameters.

The example say "Sow me all the houses of the certain typology"

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



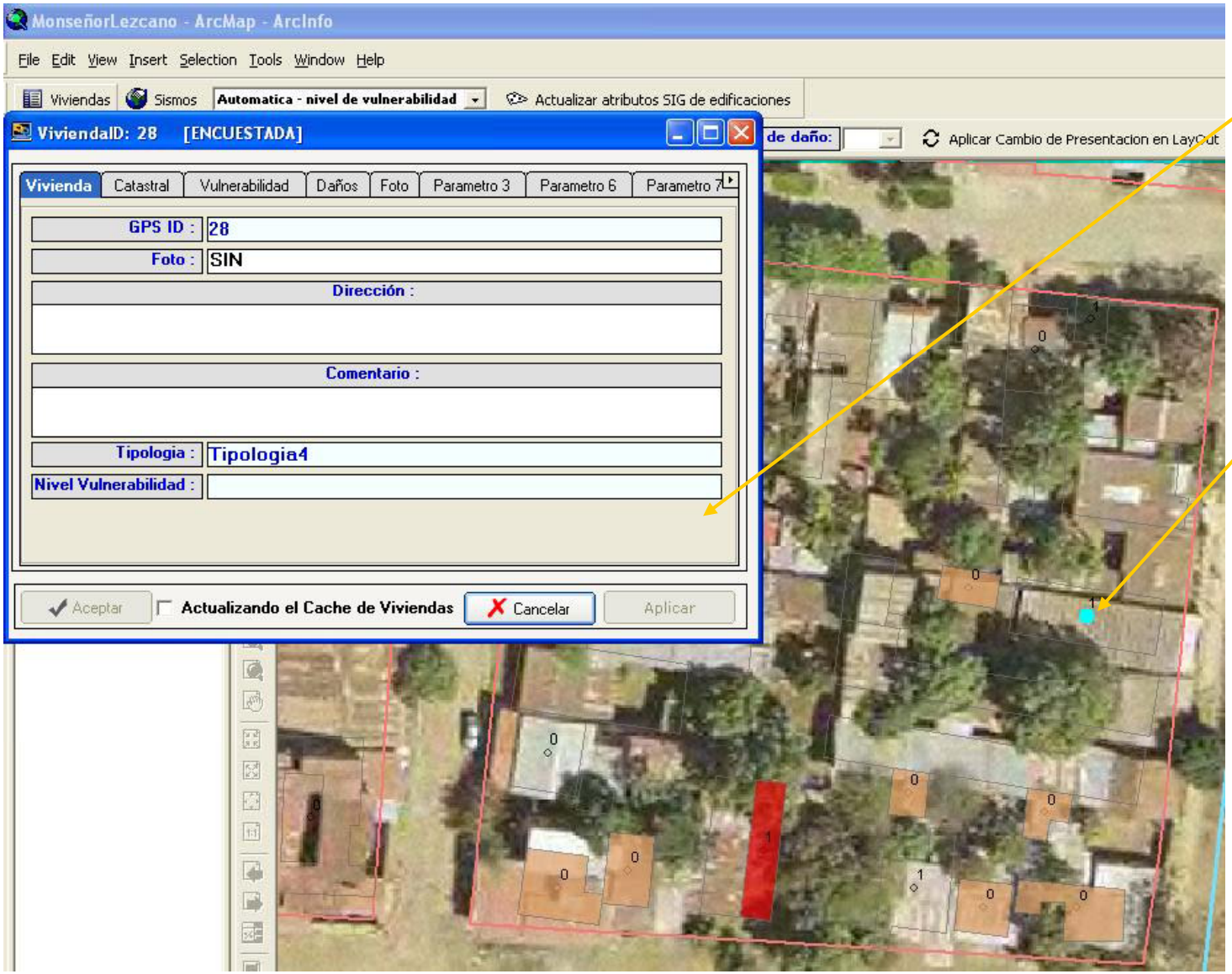
ViviendaID	Vulnerabilidad	Editada	Tipo	Tipologia	Departam	Centro	Distro	Manz	Lote	Edific
7	SIN	Falso	ENCUESTADAS	Tipologia4	10	03	U206	003	01	
9	SIN	Falso	NO_Encuestadas	Tipologia4	10	03	U206	004	00	
11	SIN	Falso	NO_Encuestadas	Tipologia4	10	03	U206	003	00	
14	SIN	Falso	ENCUESTADAS	Tipologia4	10	03	U206	005	00	
25	SIN	Falso	NO_Encuestadas	Tipologia4	10	03	U206	004	01	
28	SIN	Falso	ENCUESTADAS	Tipologia4	10	03	U206	012	01	
31	SIN	Falso	ENCUESTADAS	Tipologia4	10	03	U206	004	01	
82	SIN	Falso	ENCUESTADAS	Tipologia4	10	03	U206	014	00	
85	SIN	Falso	NO_Encuestadas	Tipologia4	10	03	U206	003	01	
116	SIN	Falso	ENCUESTADAS	Tipologia4	10	03	U206	027	01	
117	SIN	Falso	NO_Encuestadas	Tipologia4	10	03	U206	015	02	
166	SIN	Falso	ENCUESTADAS	Tipologia4	10	03	U206	021	00	
174	SIN	Falso	NO_Encuestadas	Tipologia4	10	03	U206	027	01	

Then, (from the before example) this windows show the 266 houses for the total of 2,700 that are members of the 4th typology.

At this point we can select the house that will be edited.

For example if the user select the house number 28 and then the option of “Editing the selected house”, the software will automatically bring a specialized windows for the vulnerability index purpose, that show the information about the selected house and also de software make a zoom to the house in the map.

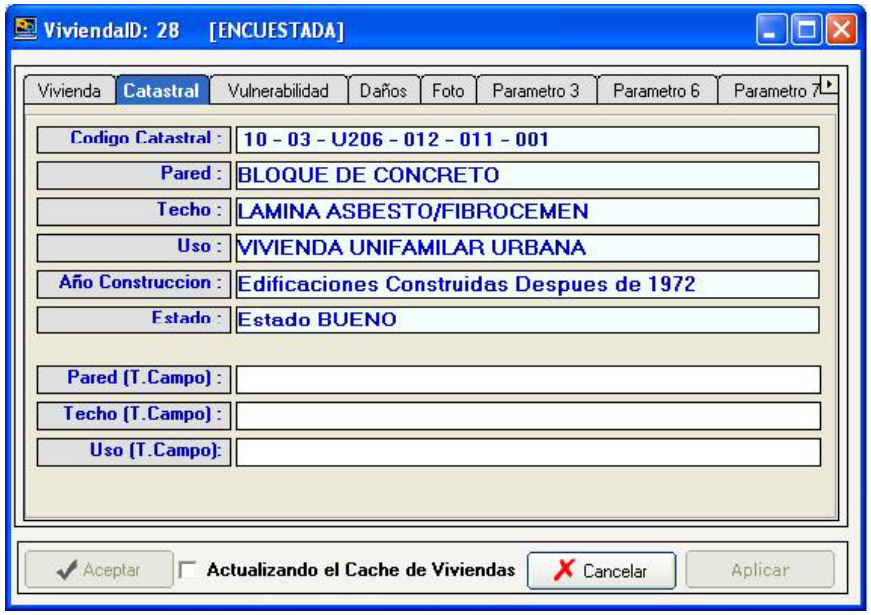
4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



Alphanumerical information of the house 28, stored in the RDBMS (Relational Database Managed System).

Graphical information of the house 28, stored in the GIS and the attribute table

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



Cadastral information for the house

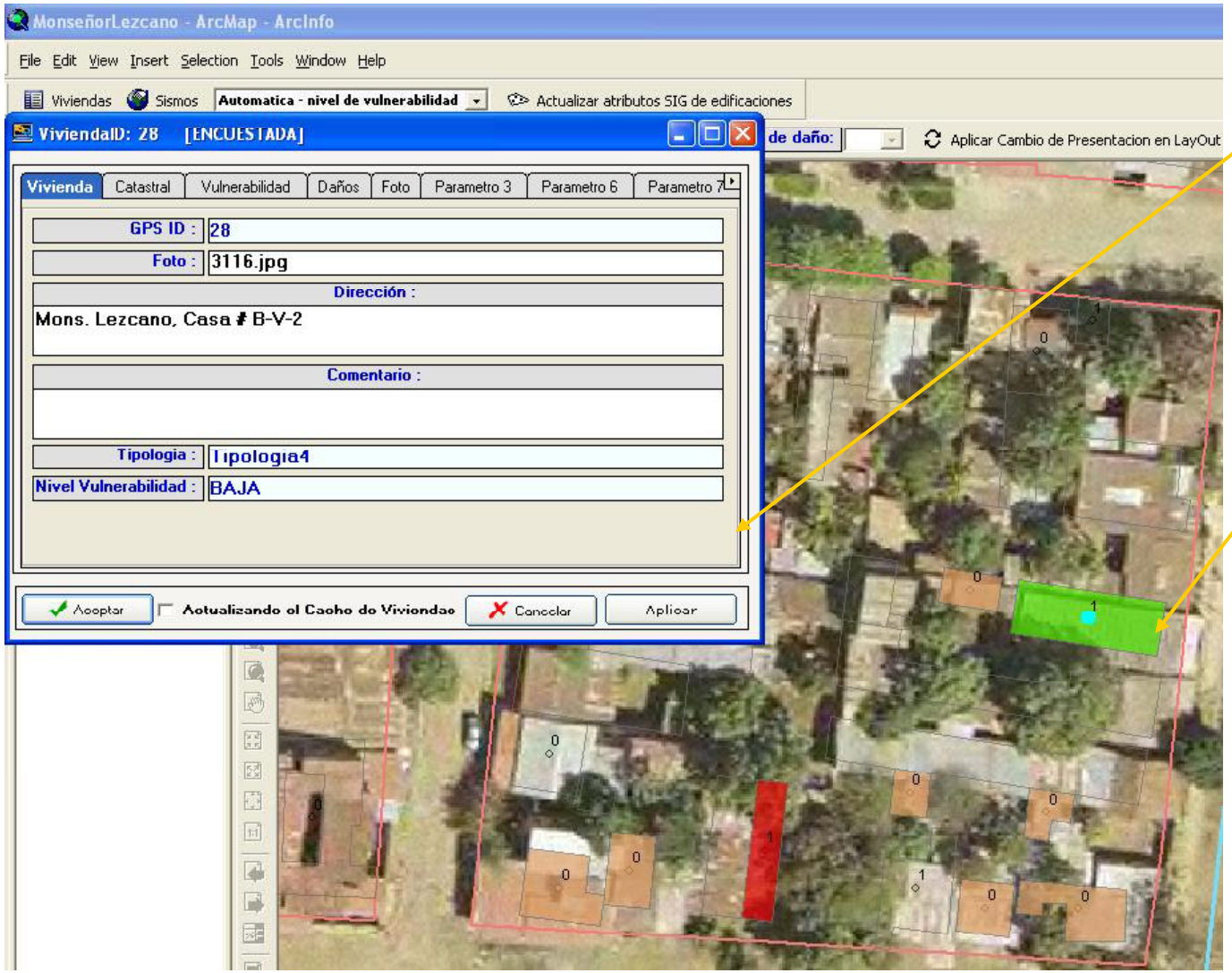
Vulnerability base information collected from the field work and the automatically calculation of the index for the software

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

Damage values for the distinct defined scenarios.

Picture of the house, took in the field work.

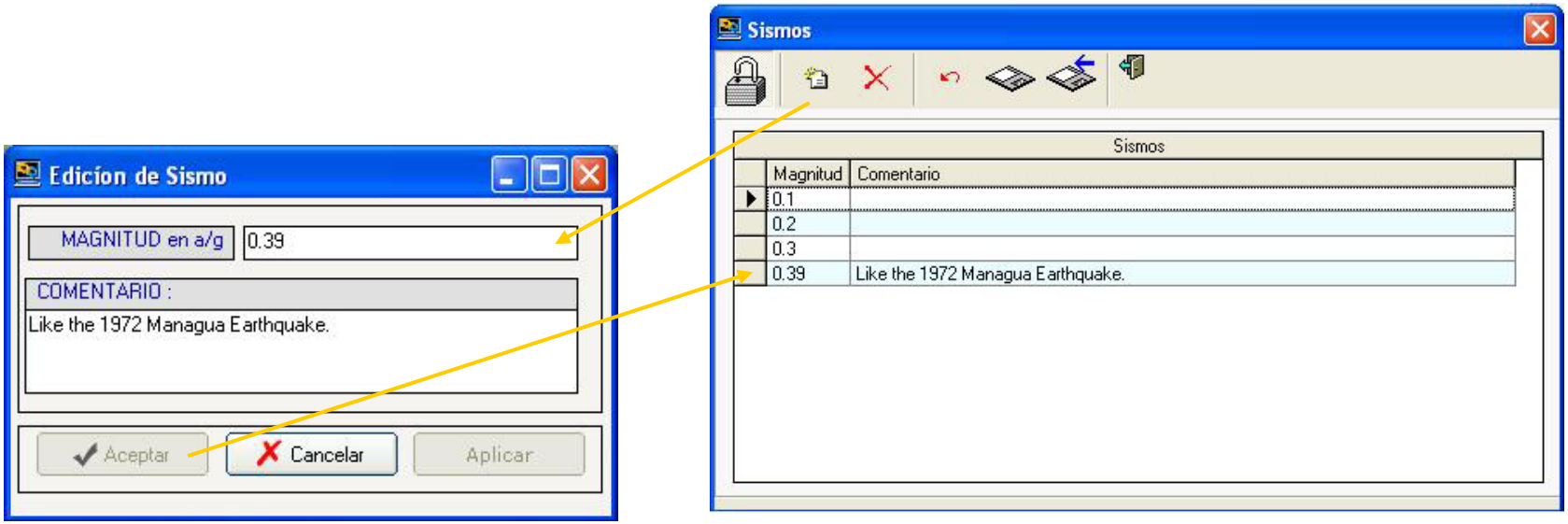
4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



House 28 After save the collected field information. We can see the automatically synchronization between the Graphical information (Behind de GIS) and Alphanumerical information (Behind the RDBM).

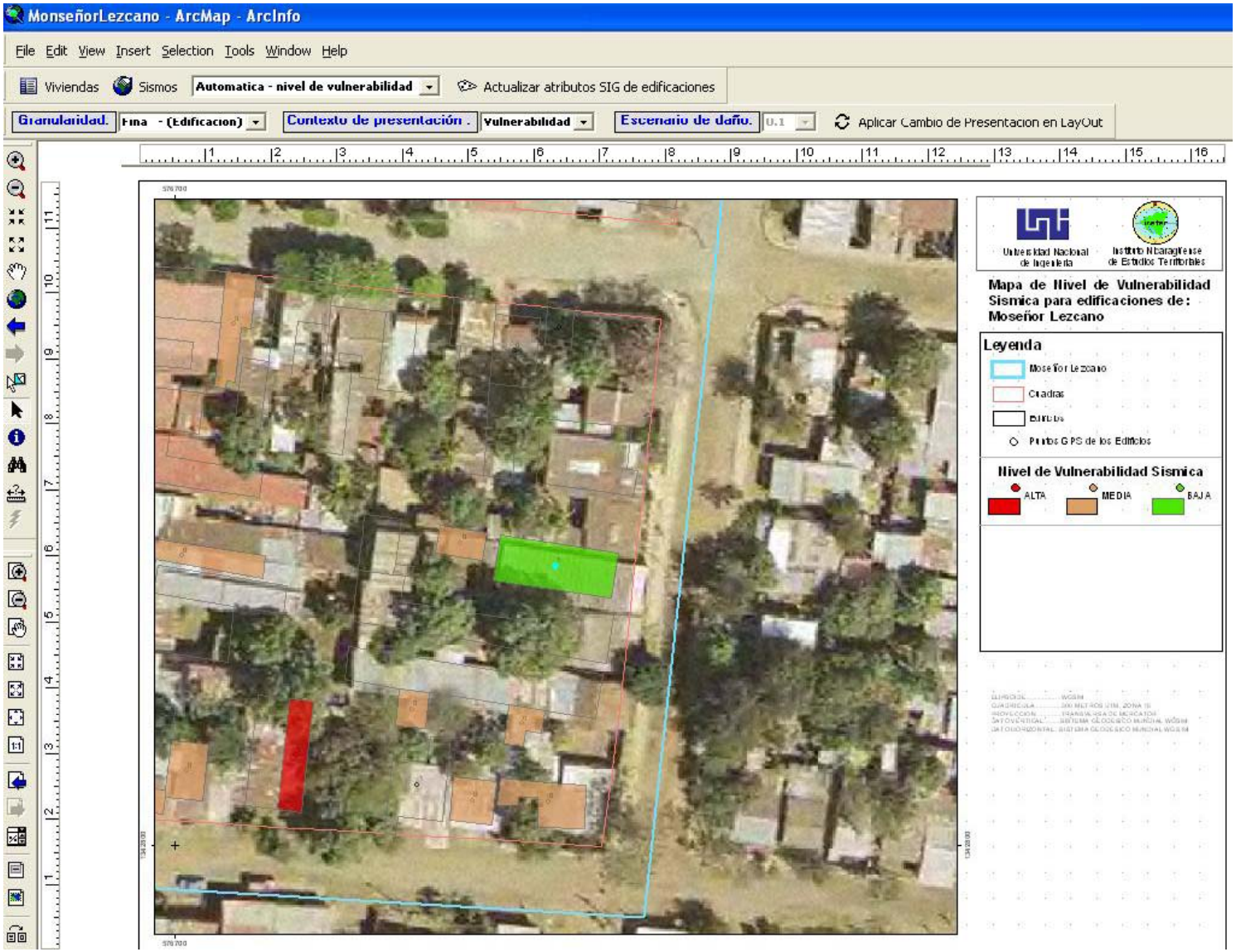
4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK

The software also allow us to create several earthquake scenarios, through the “Sismos” bottom, calculating the damages that produce the earthquake in function of each house’s vulnerability index value.

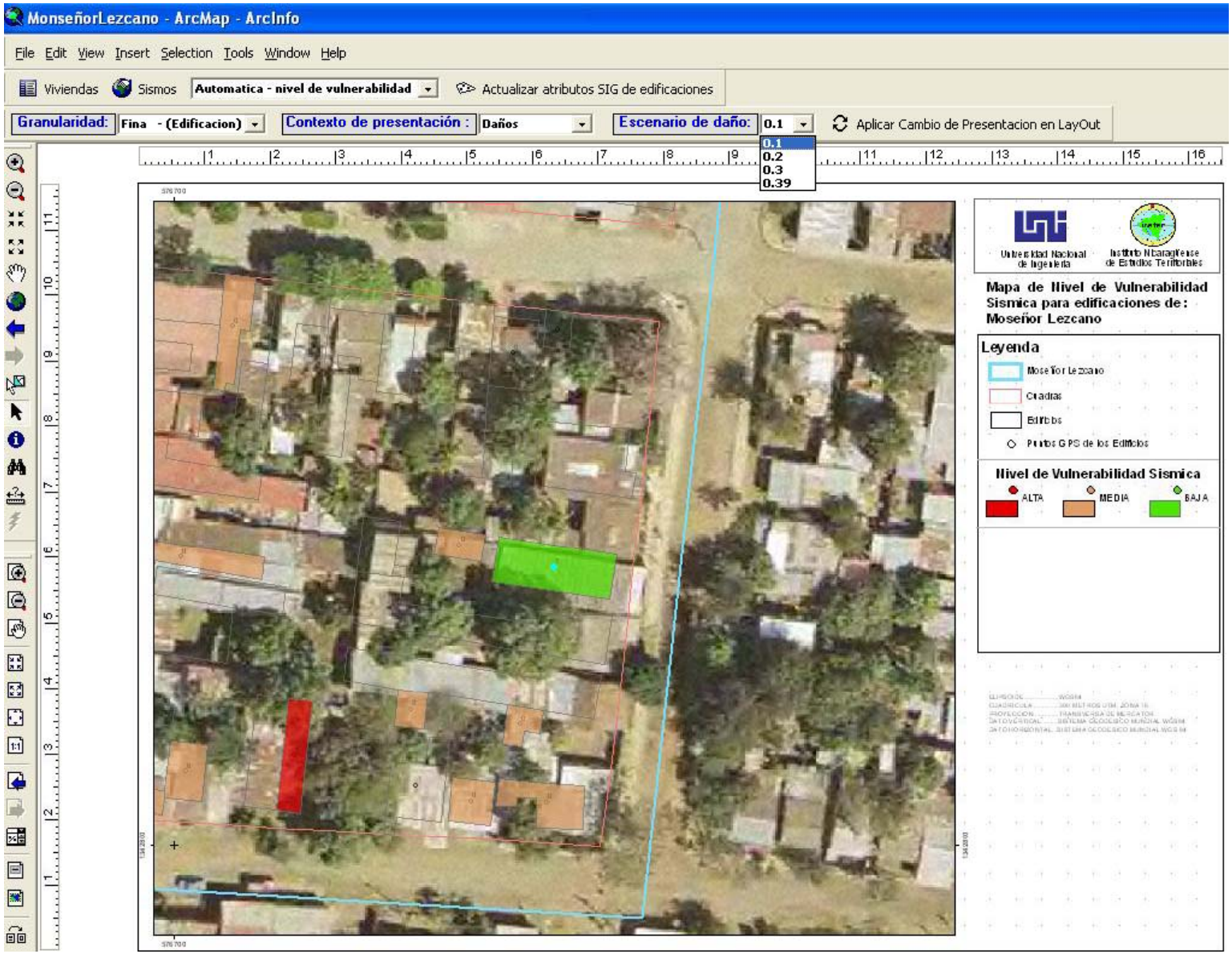


The example say “Sow me all the houses of the certain typology”

4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



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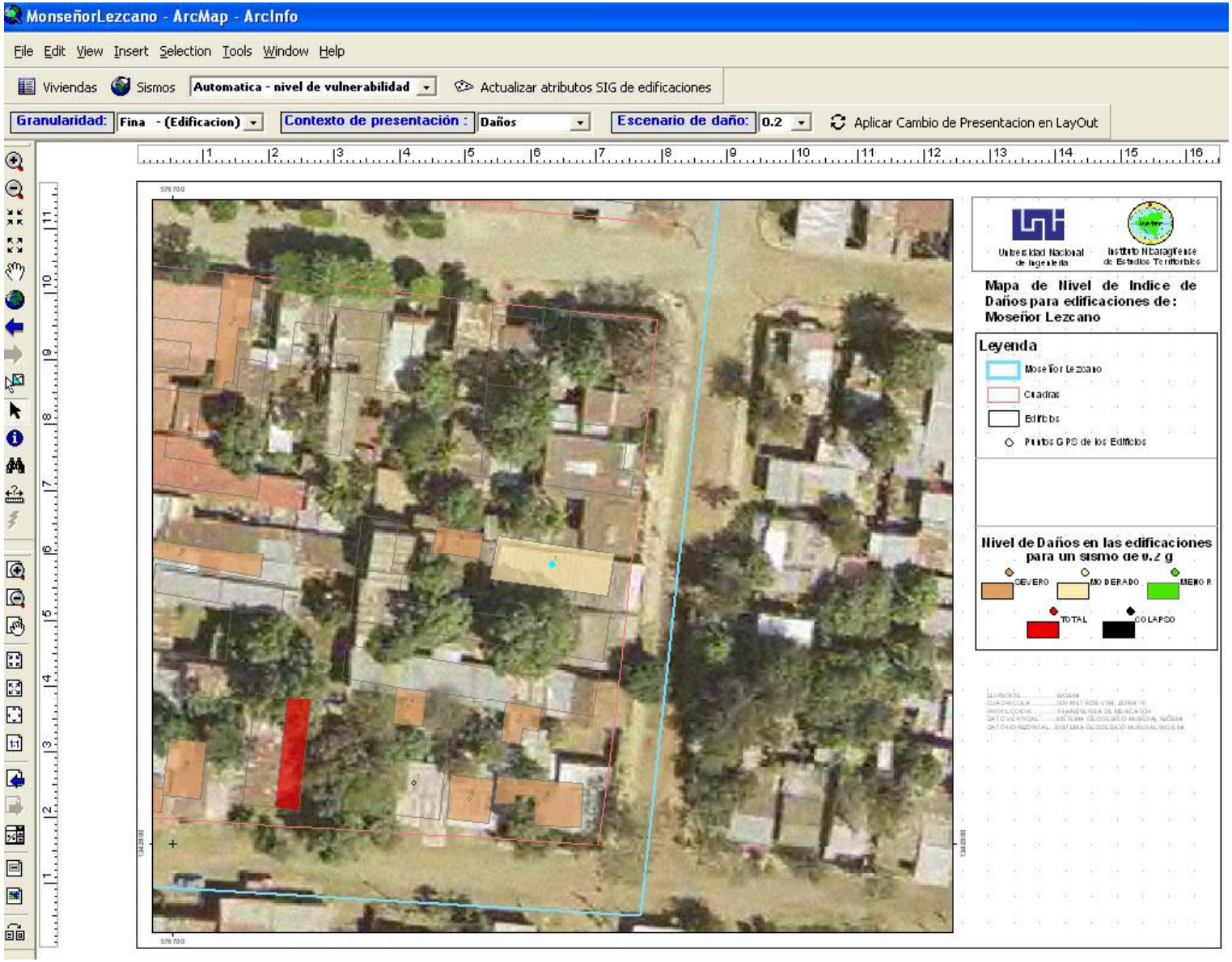

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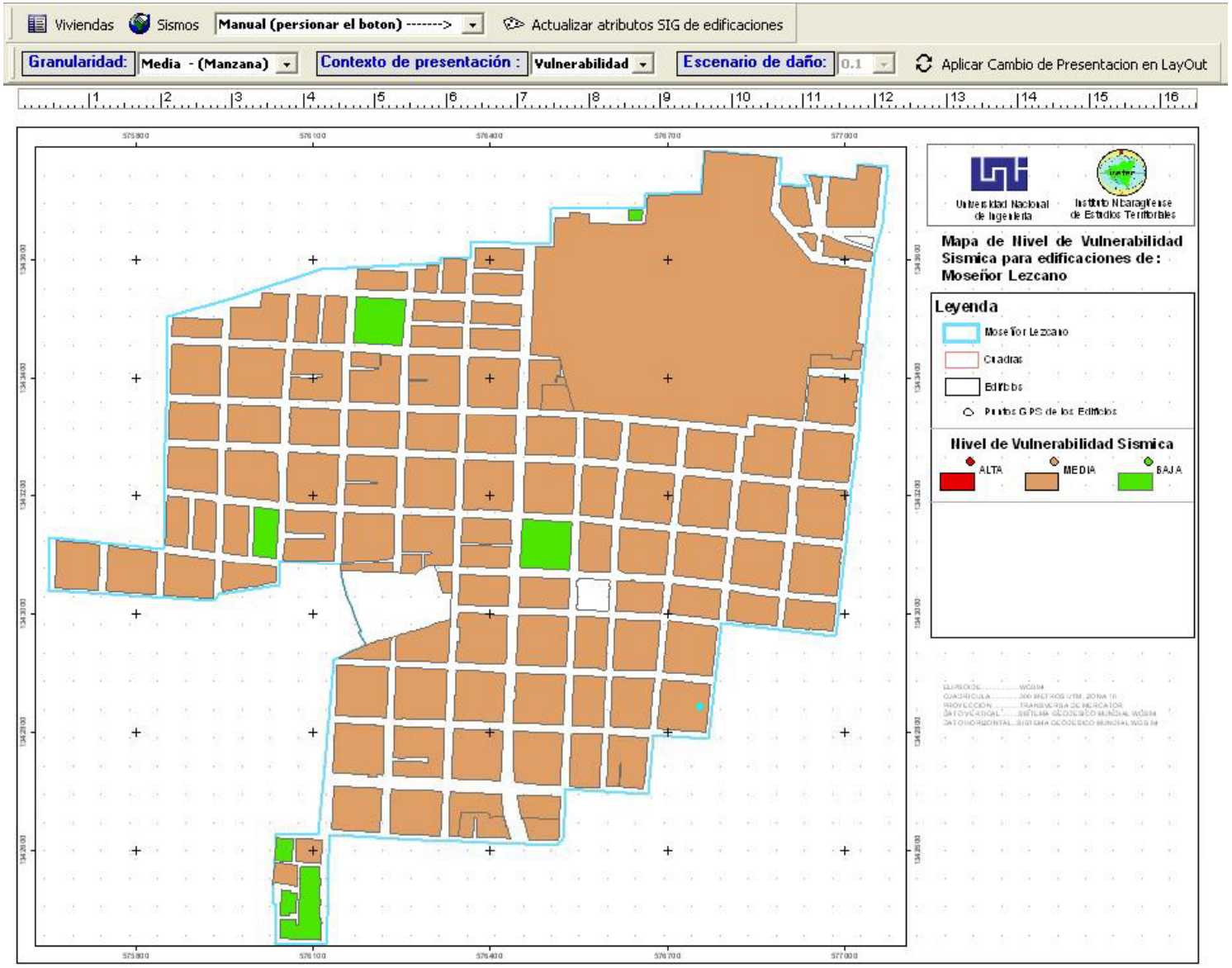
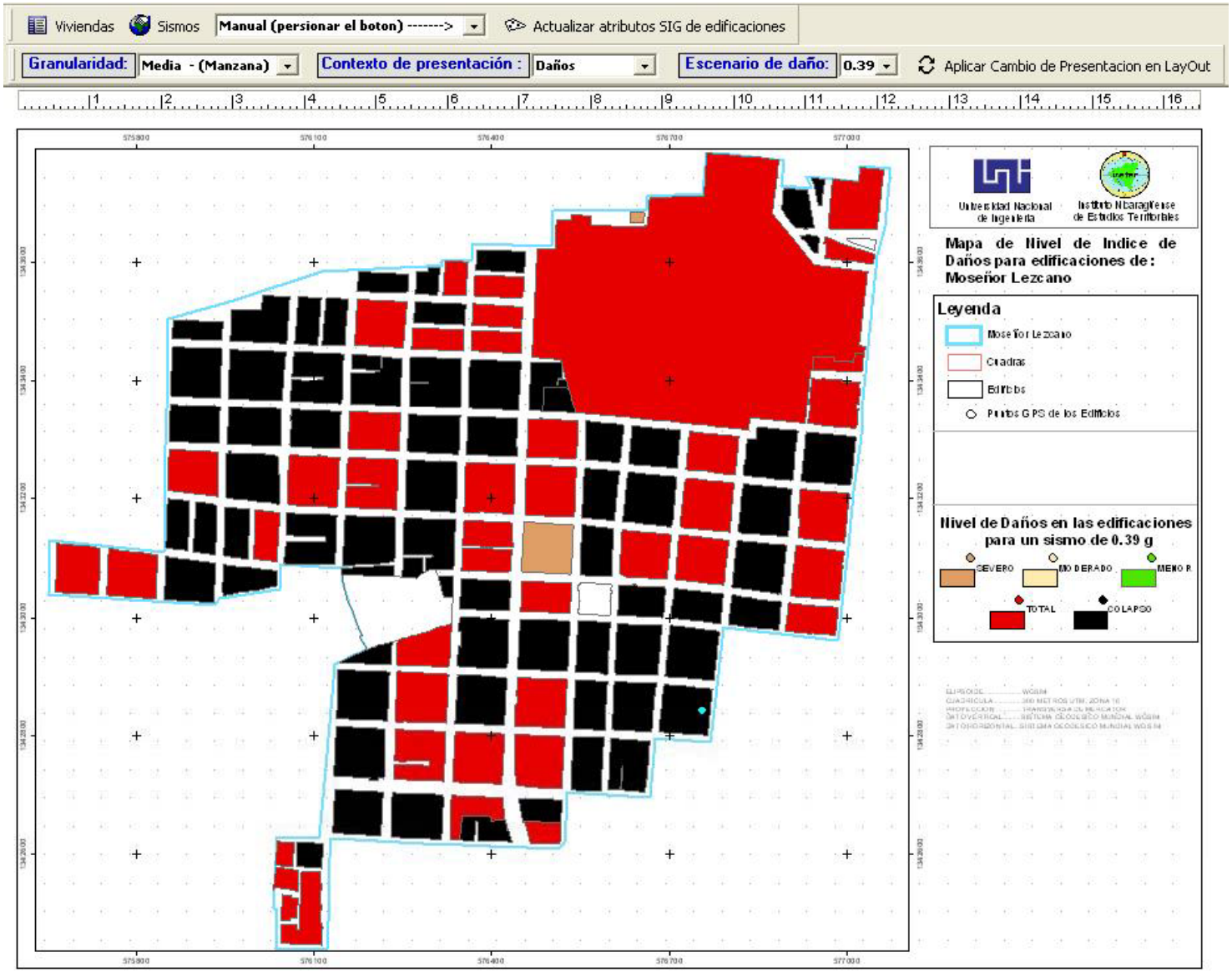


4. THE APPLICATION FUNCTIONALITIES AND ITS WAY OF WORK



CONCLUSIONS:

The new developed software reduce the amount of steps and time required for the calculation and presentation of the results on maps.

With all project data inside one program environment, the problem of make mistakes due to the translation of data between several software tools is avoided.

The program work like a Database of vulnerability due to earthquake studies.

- THE END

- *THANK YOU*

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