



LANDSLIDE DATABASE IN THE LOWER SECTION OF THE BASIN OF DEBA RIVER IN GUIPUZCOA, SPAIN: *A TOOL FOR THE DEVELOPMENT OF HAZARD AND RISK SCENARIOS*



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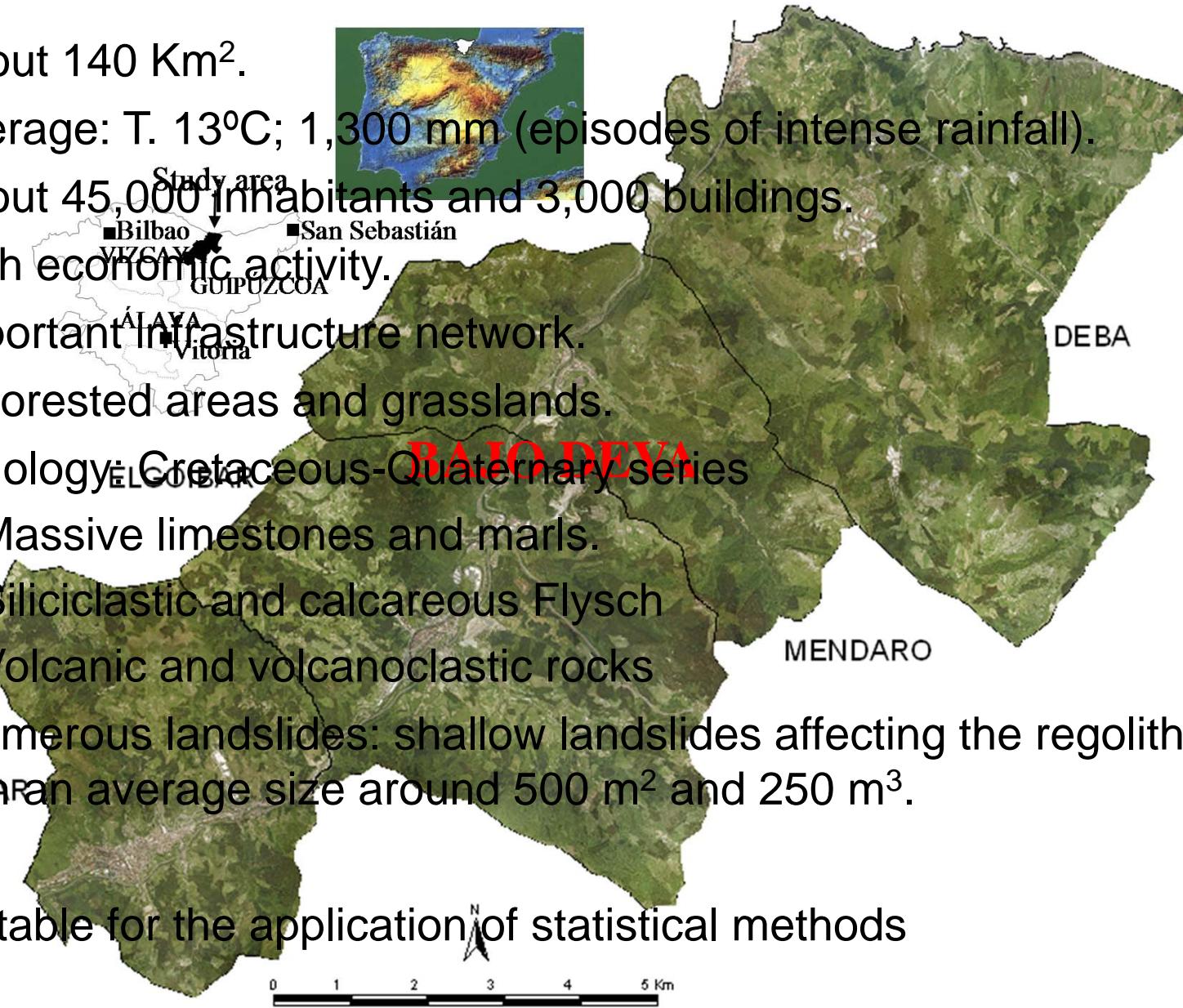
Project: Landslide hazard and risk scenarios development
Code: CGL2013-46425-P

Index

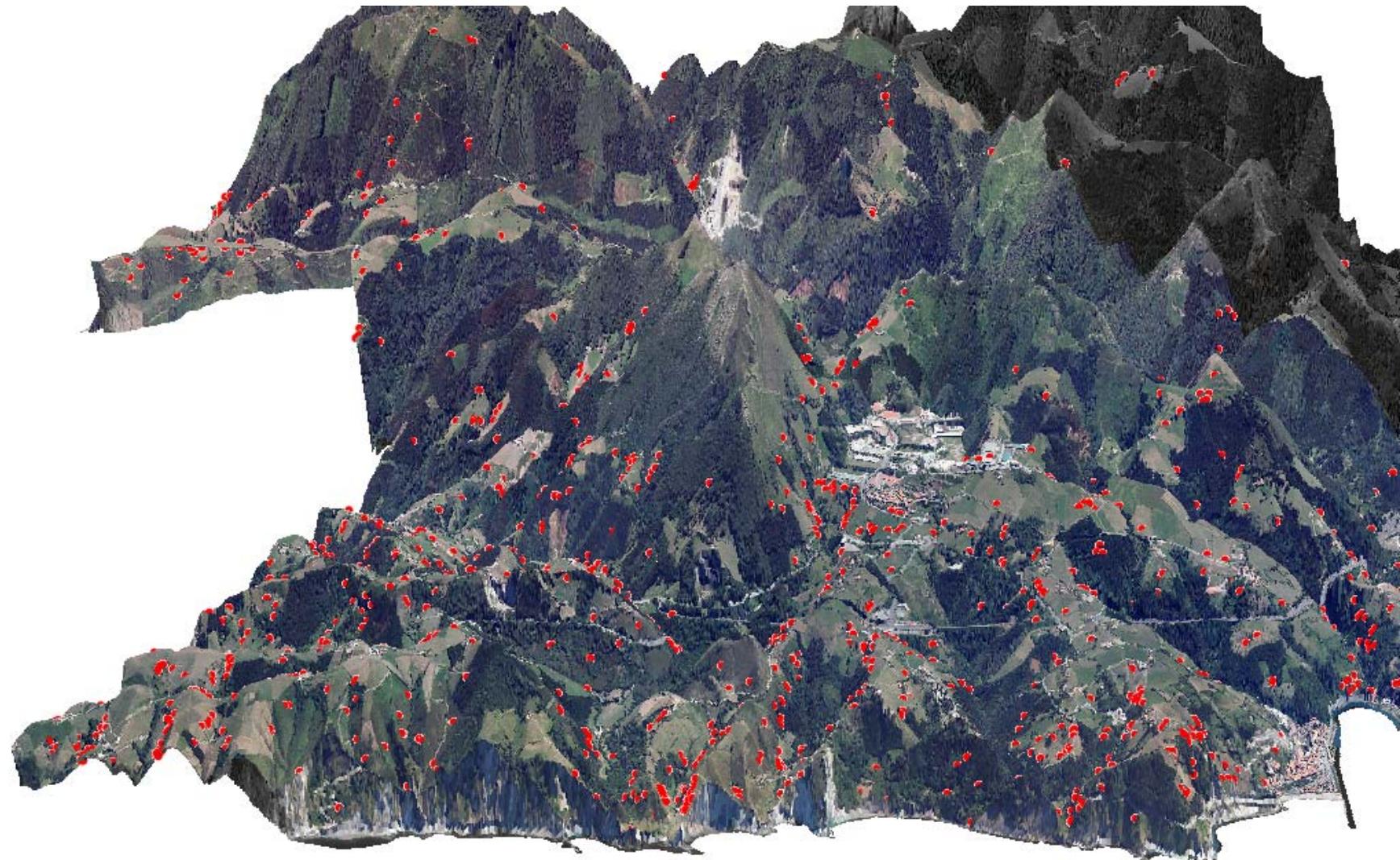
- ▶ The Project
 - ▶ Study area
 - ▶ Main goals
 - ▶ General scheme for estimate the landslide risk
 - ▶ Some basic ideas
- ▶ Development of the database (DB)
 - ▶ 0 Core landslide data
 - ▶ 1 Documents and general data
 - ▶ 2 Raw geo-spatial data
 - ▶ 3 Causal geo-factors
 - ▶ 4 Exposed elements
 - ▶ 5 Susceptibility
 - ▶ 6 Hazard
 - ▶ 7 Vulnerability
 - ▶ 8 Risk
- ▶ Conclusions

Study area

- ▶ About 140 Km².
- ▶ Average: T. 13°C; 1,300 mm (episodes of intense rainfall).
- ▶ About 45,000 inhabitants and 3,000 buildings.
- ▶ High economic activity.
- ▶ Important Infrastructure network.
- ▶ Reforested areas and grasslands.
- ▶ Lithology: Cretaceous-Quaternary series
 - ▶ Massive limestones and marls.
 - ▶ Siliciclastic and calcareous Flysch
 - ▶ Volcanic and volcanoclastic rocks
- ▶ Numerous landslides: shallow landslides affecting the regolith, with an average size around 500 m² and 250 m³.
- ▶ Suitable for the application of statistical methods



Study area. Point of view: from the sea



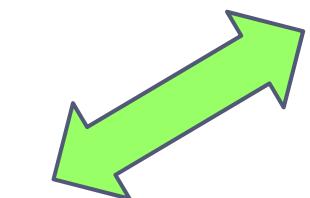
Main goals

- ▶ Development of **landslide susceptibility, hazard and risk models**, analyzing landslides occurred in the recent past to mitigate the risk.
 - ▶ Design and develop of a **geo-database to analyze and construct the models.**

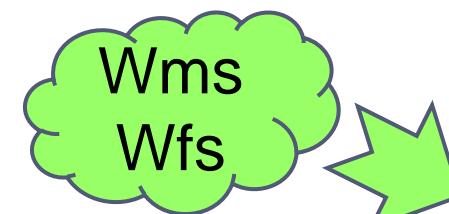
Database

- 0 Core: landslides
- 1 Docs and general data
- 2 Raw geo-spatial data
- 3 Causal geo-factors
- 4 Exposed elements
- 5 Susceptibility
- 6 Hazard
- 7 Vulnerability
- 8 Risk**

database manager: ArcGis
Personal & File Geodatabase

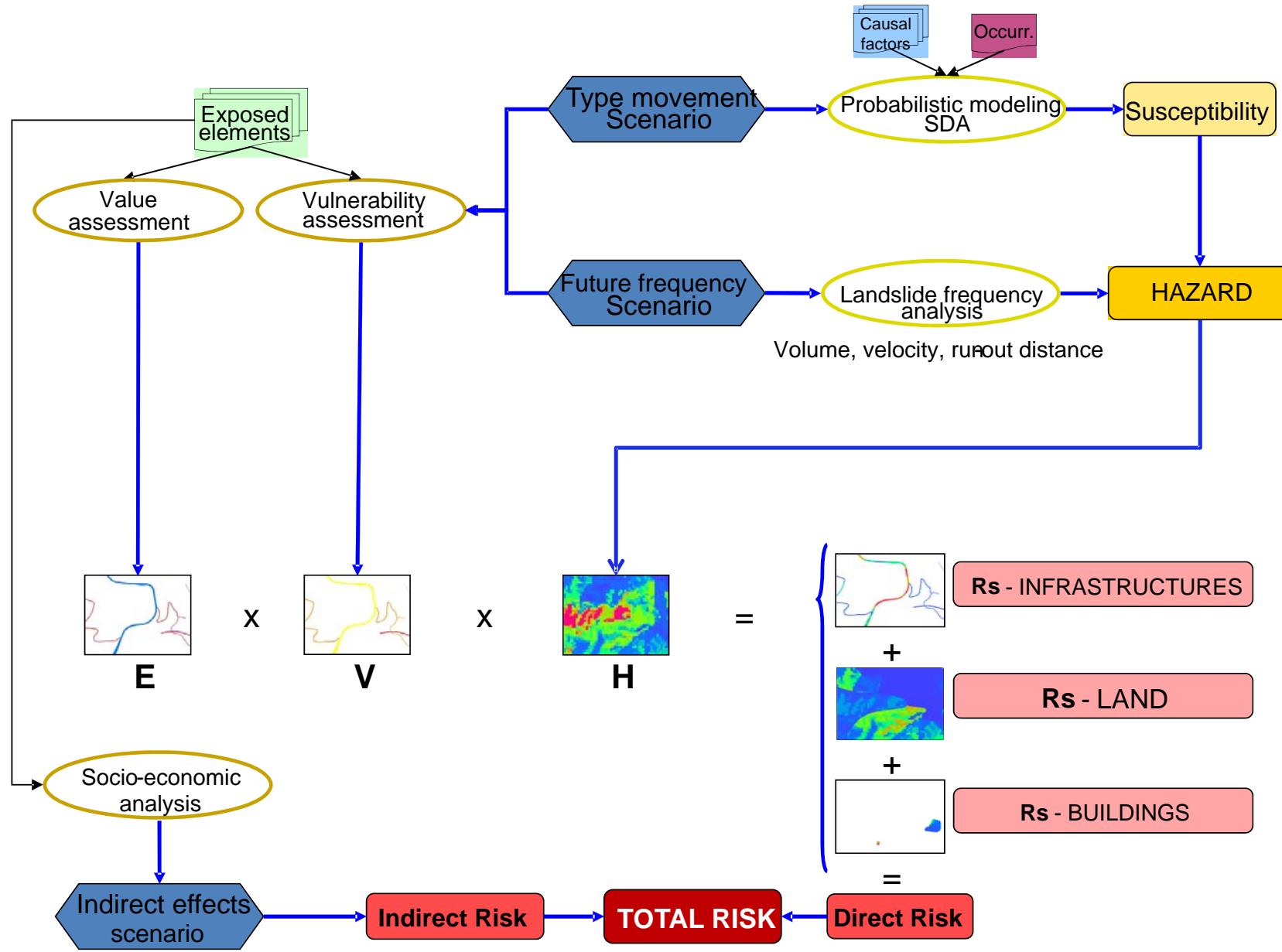


Create, edit,
visualize and
analyze
spatial data



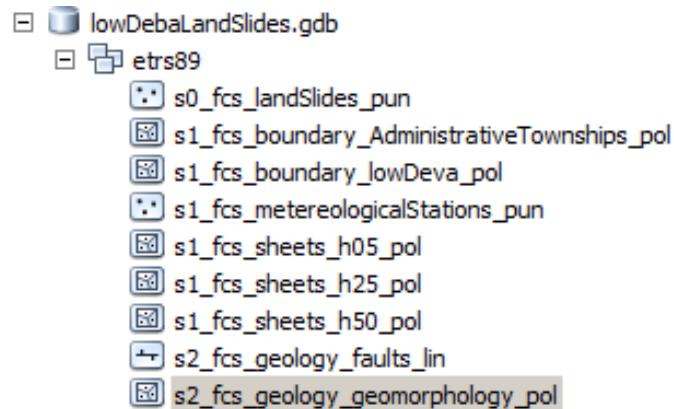
Visualize
spatial data

General scheme for estimate the landslides risk



Some basic ideas

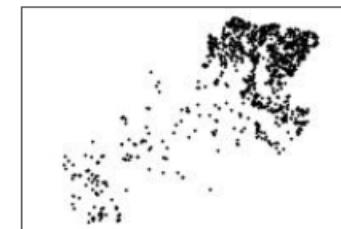
- ▶ Reference coordinate system.
 - ▶ ETRS89, UTM30N; msl Alicante
- ▶ Detail level and cell size:
 - ▶ Typical 1:5.000, and cell size 5 m.
- ▶ Normalization of names:
 - ▶ s[#]_[type]_key1_key2_[geo],
where:
 - ▶ # is a state [0-8]
 - ▶ Type is *fcs*(vector feature class),
tbl (tabular data), *ortho*
(orthophoto), *map* (scanned
map), *las* (LiDar), *dtm* and *grd*
(raster data).
 - ▶ Geo, is the geometry: *pun*
(point), *lin* (line) or *pol* (polygon).
- ▶ Date as key field
- ▶ Set domain values.
- ▶ Set metadata.



OBJECTID_12	
LS_CODE	
LS_TYPE	shallow slide
LS_SOURCE	
LS_TRIGGERING_FACTOR	other
LS_IMPACT_TYPE	<Null>
DATE_OF_YEAR	rainfall
DATE_FROM	man-made works
DATE_TO	other
YEAR_CODE	erosion
LOCATION_CX	water leakage

s0_fcs_landSlides_pun

File Geodatabase Feature Class



Tags

There are no tags for this item.

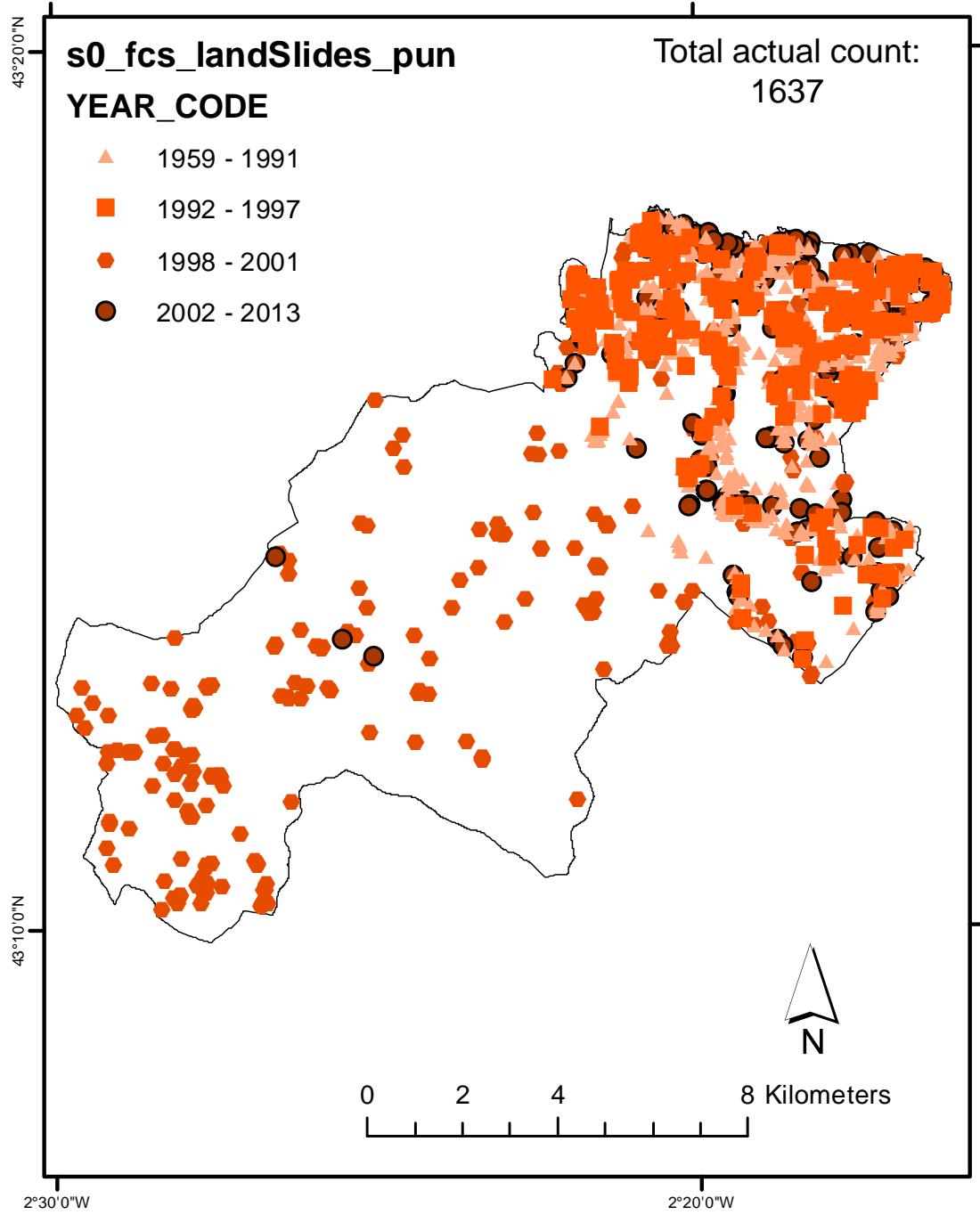
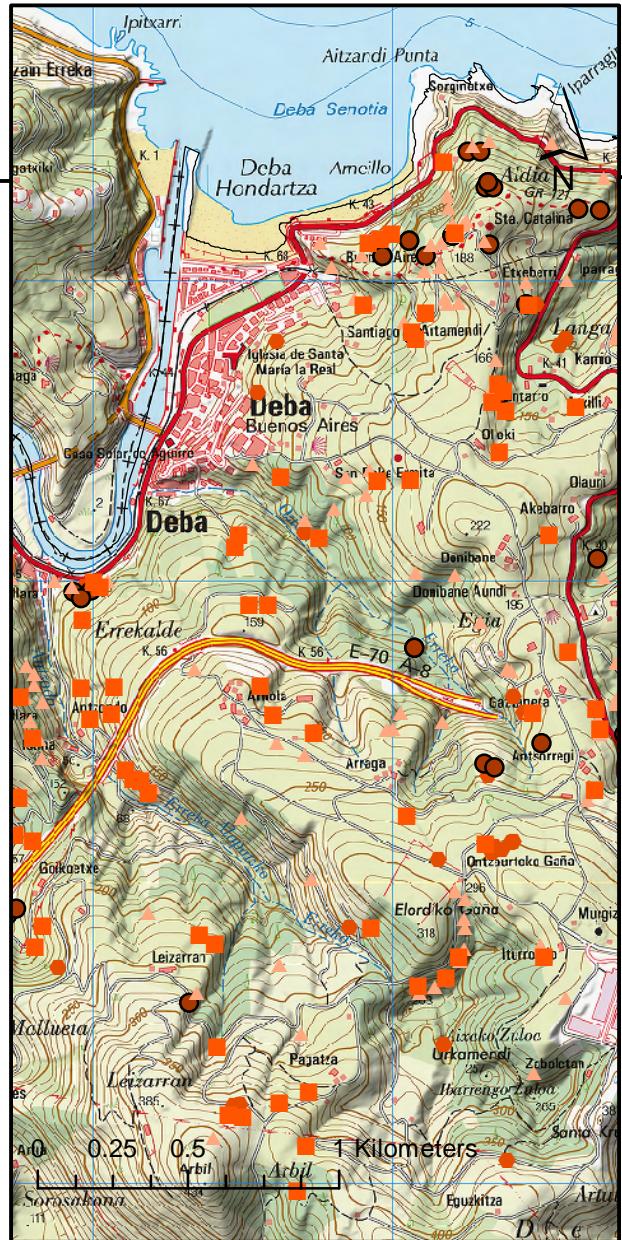
Summary

There is no summary for this item.

Description

core attributes for landslides in Low Deba, Guipuzcoa, Spain

Landslide database in lower Deba valley (Guipuzcoa, Spain)
2 DB 0 Core landslide data



0 Core landslide data



2003



2004



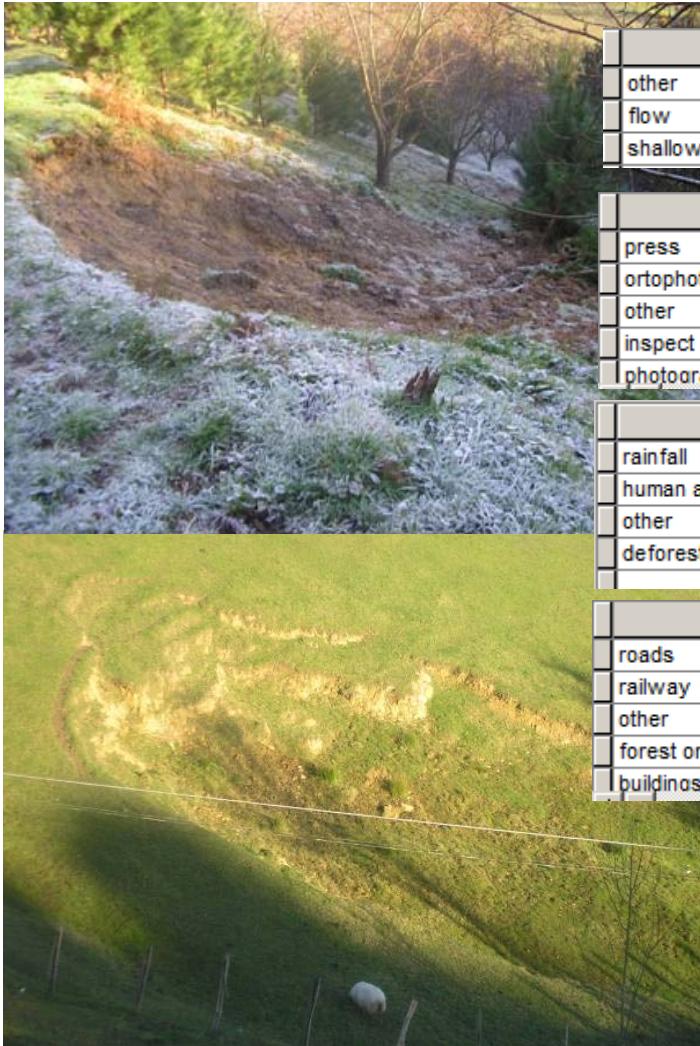
2011



2013

Landslide features disappear soon after its occurrence

0 Core landslide data



Code
other
flow
shallow slide

Code
press
orthophotography
other
inspect
photoGRAMMATIC model

Code
rainfall
human activity
other
deforestation

Code
roads
railway
other
forest or agricultural area
buildings

YEAR_CODE
1959
1970
1983
1985
1991
1993
1997
2001
2006
2008
2013

Identify

Identify from: <Top-most layer>

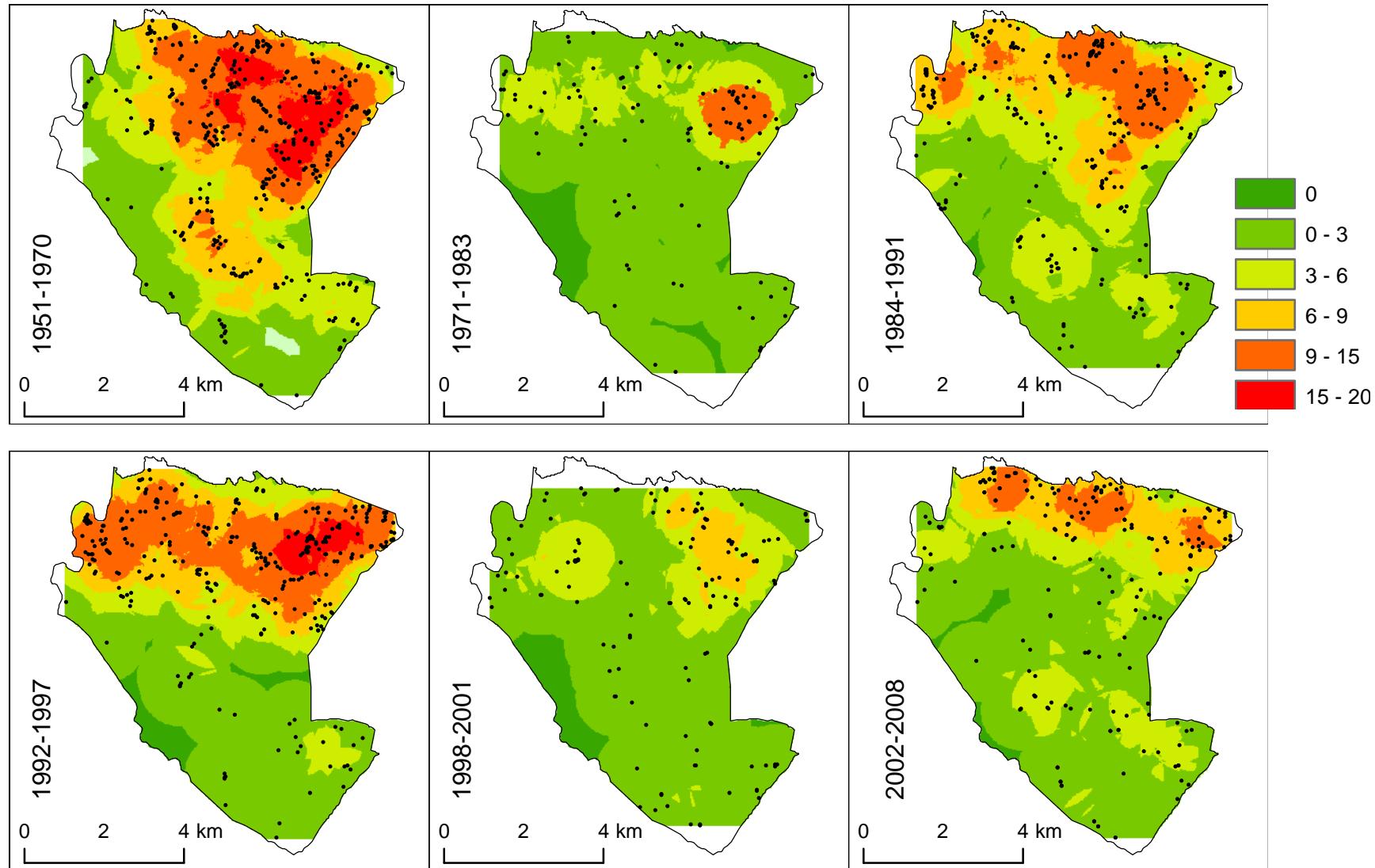
Location: 553,074.492 4,792,779.013 Meters

Field	Value
OBJECTID_12	171
Shape	Point
LS_CODE	200655307479277ap
LS_TYPE	shallow slide
LS_SOURCE	orthophotography
LS_TRIGGERING_FACTOR	rainfall
LS_IMPACT_TYPE	forest or agricultural area
DATE_OF_YEAR	<null>
DATE_FROM	01/01/2002
DATE_TO	31/12/2006
YEAR_CODE	2006
LOCATION_CX	553076
LOCATION_CY	4792775
LOCATION_H	160
LOCATION_MUNICIPALITY	Deba
LOCATION_TOPOONYM	Egia
LOCATION_BASIN	Deba
LOCATION_SUBBASIN	Ozio

Identified 2 features

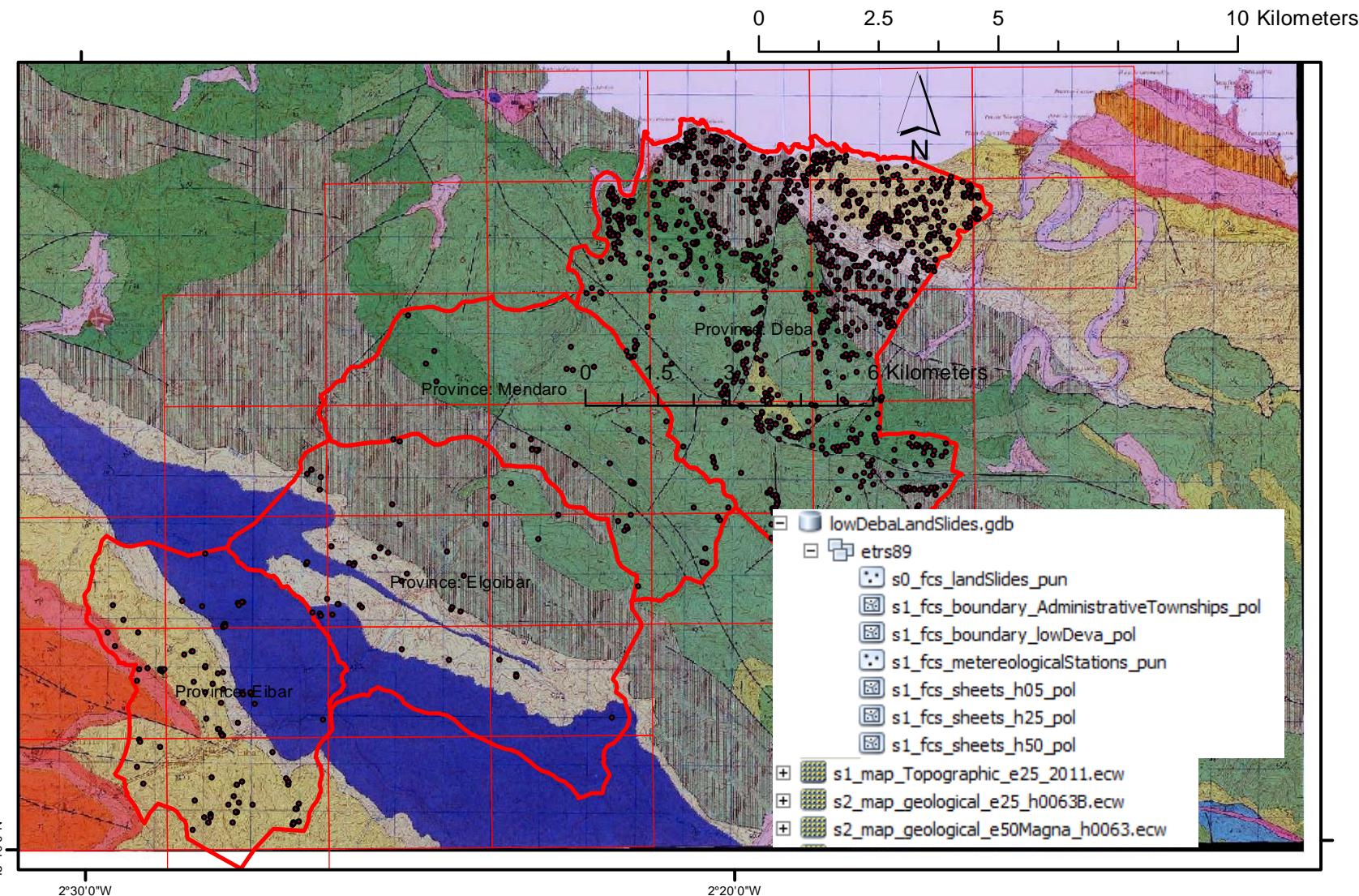
0 Core landslide data.

- ▶ Landslide density maps, radius 1000 m; and landslide ruptures (points), municipality of Deba



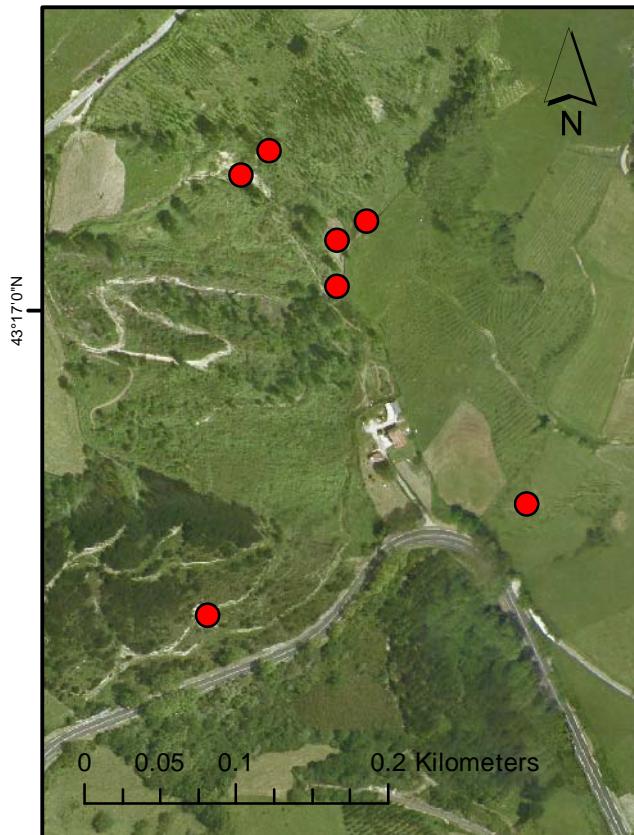
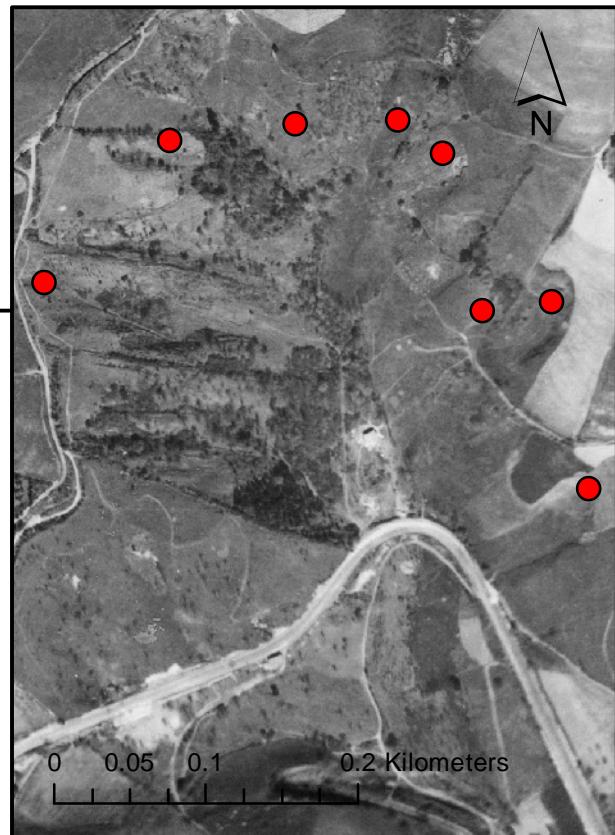
1 Documents and general data

- ▶ Administrative boundaries, river basins, map sheets, topographic raster maps, geological raster maps, ...



2 Raw geo-spatial data

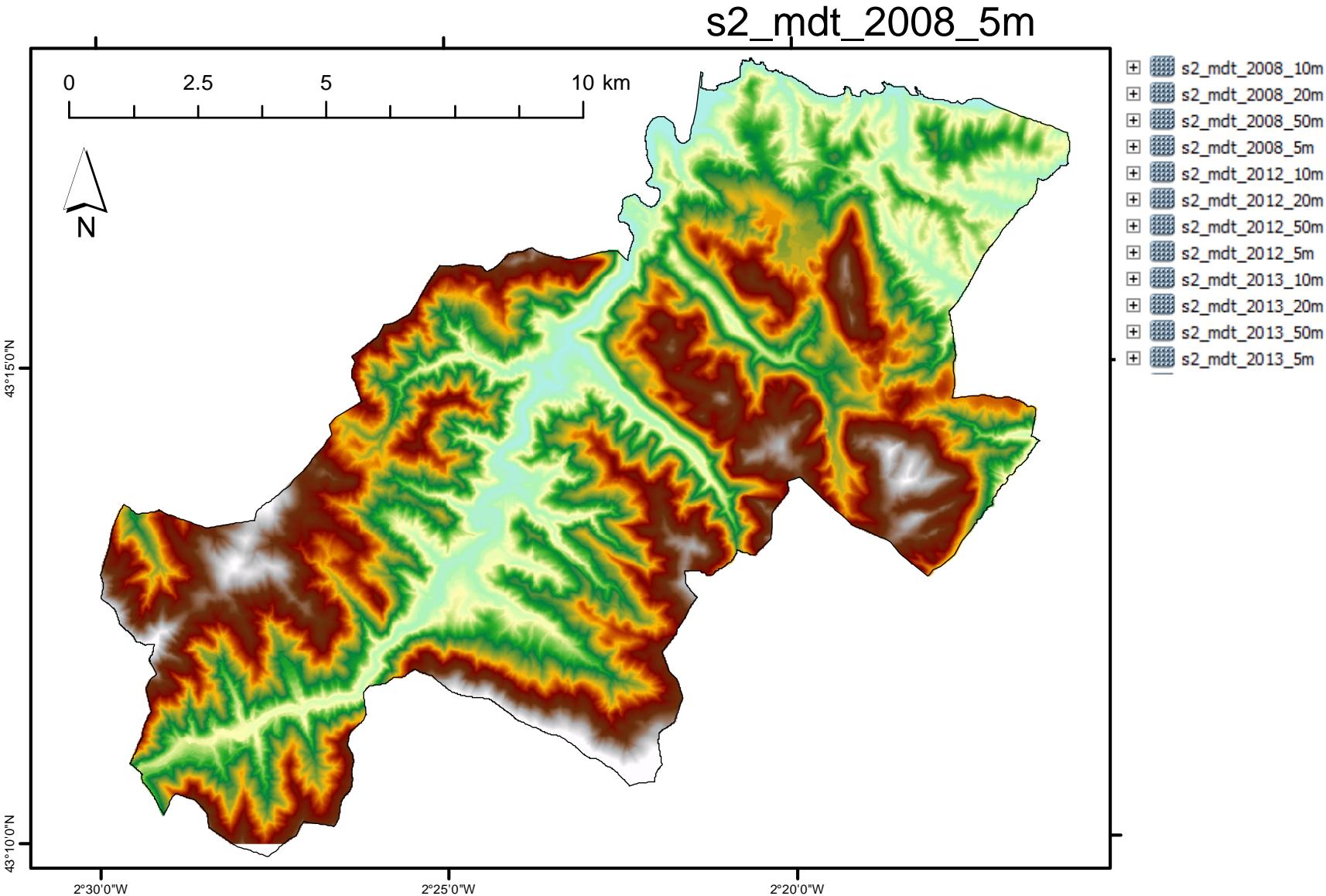
- ▶ **Ortophotos**, digital terrain models, raw topographies maps, raw precipitation tabular data...



- + s2_ortho_LowDeba_1954.ecw
- + s2_ortho_LowDeba_1983.ecw
- + s2_ortho_LowDeba_1991.ecw
- + s2_ortho_LowDeba_1997.ecw
- + s2_ortho_LowDeba_2001.ecw
- + s2_ortho_LowDeba_2002.ecw
- + s2_ortho_LowDeba_2004.ecw
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- + s2_ortho_LowDeba_2006.ecw
- + s2_ortho_LowDeba_2007.ecw
- + s2_ortho_LowDeba_2008.ecw
- + s2_ortho_LowDeba_2009.ecw
- + s2_ortho_LowDeba_2010.ecw
- + s2_ortho_LowDeba_2011.ecw
- + s2_ortho_LowDeba_2012.ecw
- + s2_ortho_LowDeba_2013.ecw
- + s2_ortho_LowDeba_2014.ecw

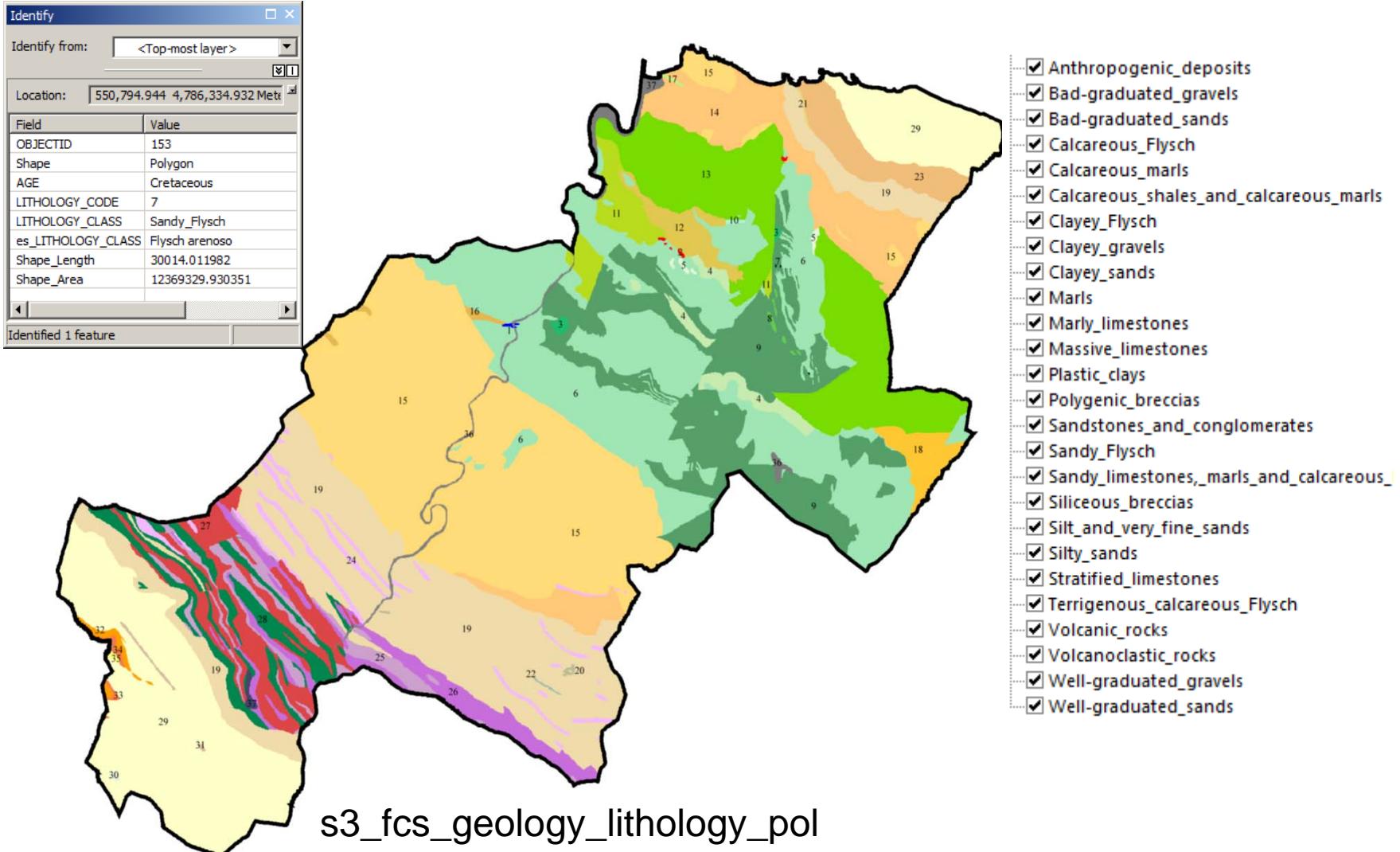
2 Raw geo-spatial data

- Ortophotos, **digital terrain models**, raw topographies maps, raw precipitation tabular data...

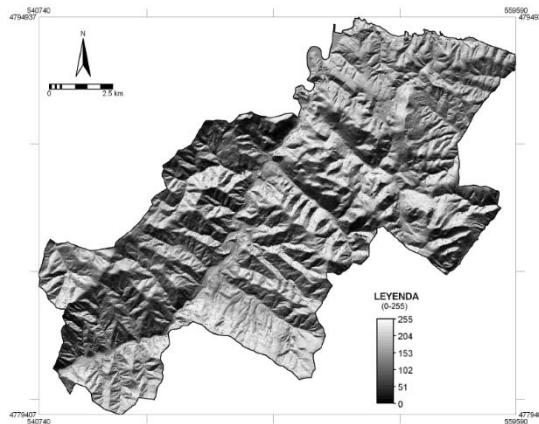


3 Causal geo-factors

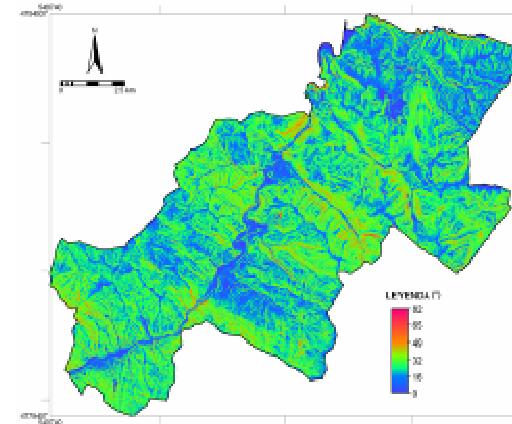
- ▶ **Lithology**, Vegetation, DEM derivate (slope, aspect, curvature, etc.), precipitation, etc.



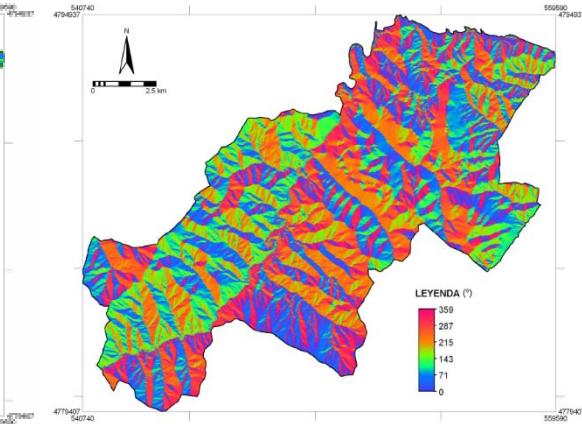
3 Causal geo-factors



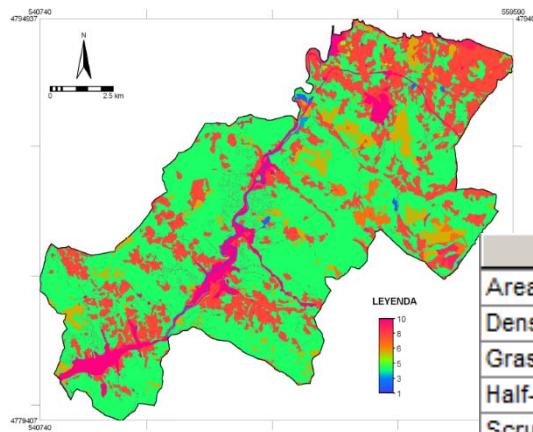
Insolation



Slope gradient



Aspect

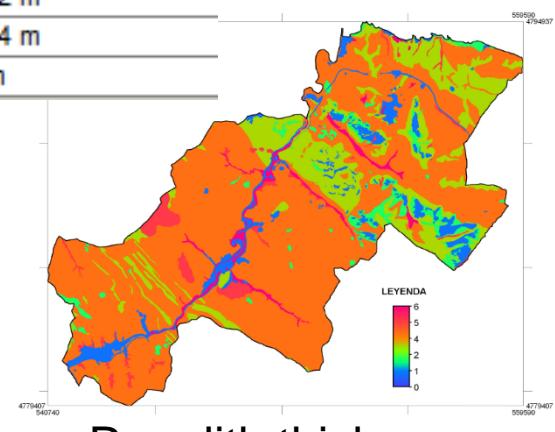


Vegetation

VEG_CLASS	
Areas without vegetation (urban areas)	
Dense deciduous forest (beech woods)	
Grasslands and cultivation	
Half-open deciduous forest	
Scrubs and bushes	
Very dense coniferous forest	
Very dense forest (oak and Quercus ilex woods)	

REGOLITH_THICKNESS

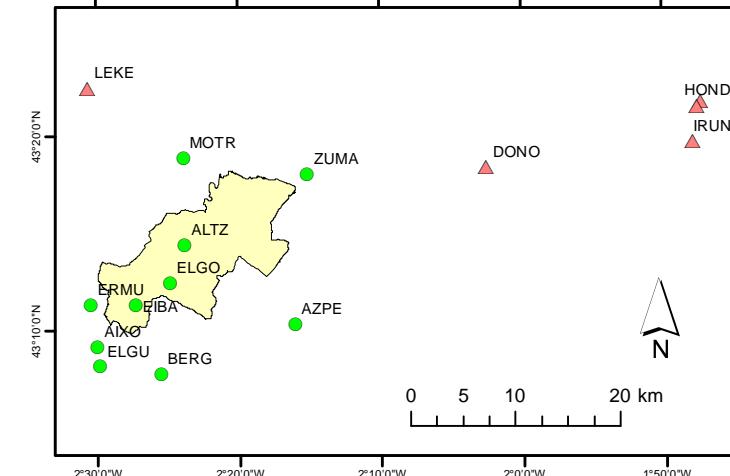
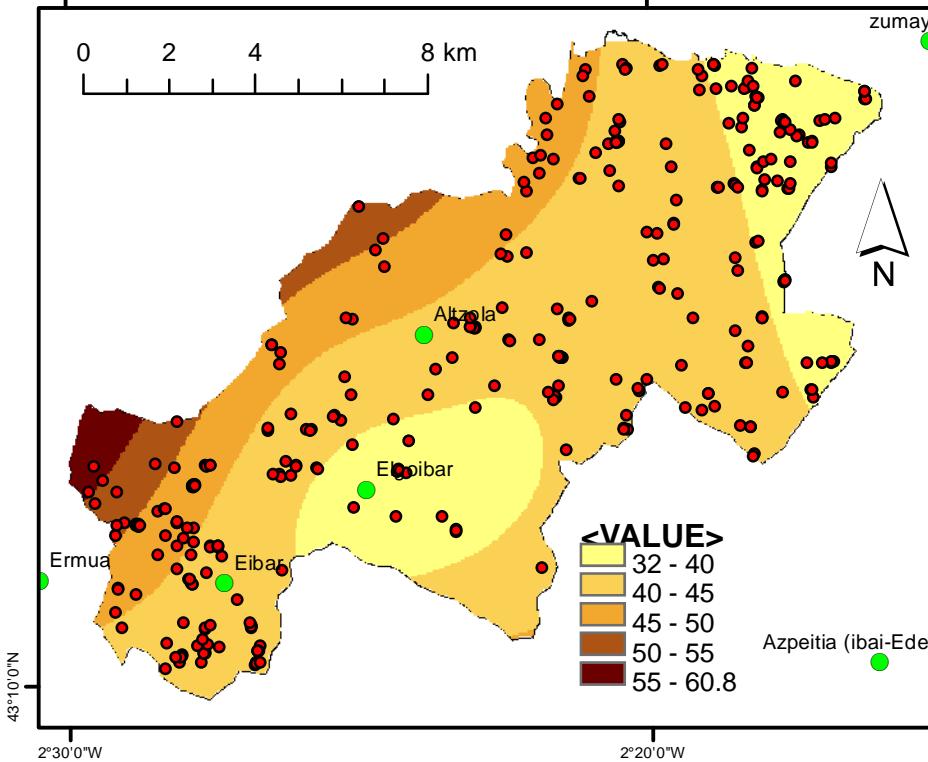
- From 0 to 0.5 m
- From 0.5 to 1 m
- From 1 to 2 m
- From 2 to 4 m
- Higher 4 m



Regolith thickness

3 Causal geo-factors

- Precipitation: Highest hourly precipitation (mm) per year.
Interpolation model: Spline, regularized, weight 0,1 and 12 points



s2_fcs_precipitationsYearly_pun

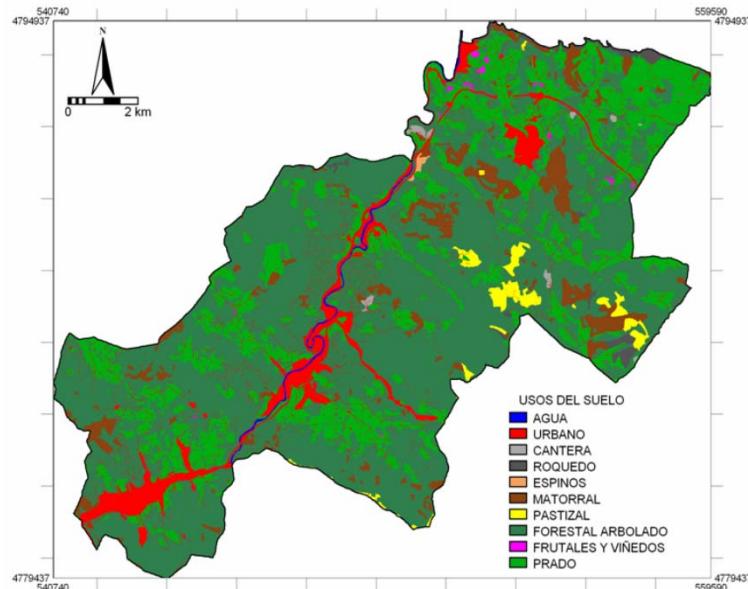
OBJEC	EstationName	YEAR	P24_percentile	P24_mean	P24_min	P24_max	P24_sum	P24_range	P24_stdev	P24_median	P24_numCount	P24_count
20	Ermua	2001	1	3.200548	0	51.5	1168.2	51.5	7.274757	0	365	365
37	Aixola	2001	0.99	2.355587	0	36.5	843.3	36.5	5.167569	0	358	365
114	Bergara (Albitxu)	2001	1	3.230959	-0.4	56.4	1179.3	56.8	7.337769	0	365	365
130	Elgoibar	2001	0.95	2.464451	0	38.6	852.7	38.6	5.916886	0.1	346	365
156	Altzola	2001	1	3.087671	0	43.5	1127	43.5	6.629449	0	365	365
182	zumaya	2001	1	1.774795	0	28.8	647.8	28.8	4.018456	0	365	365

(0 out of 6 Selected)

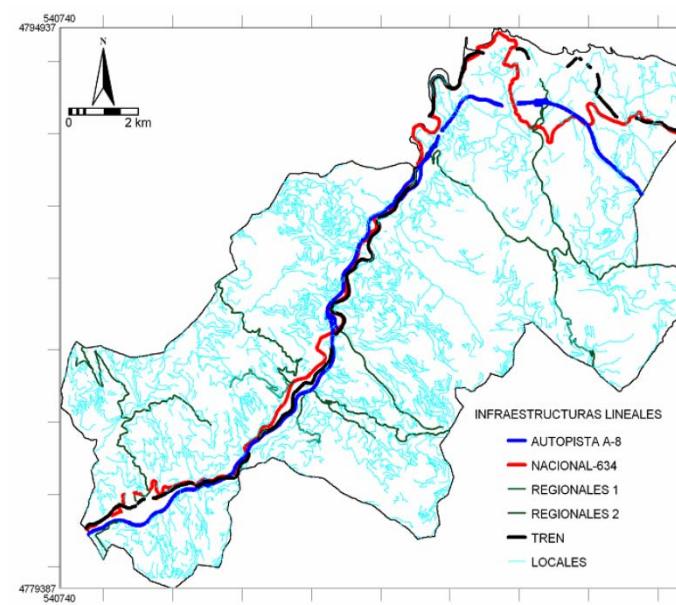
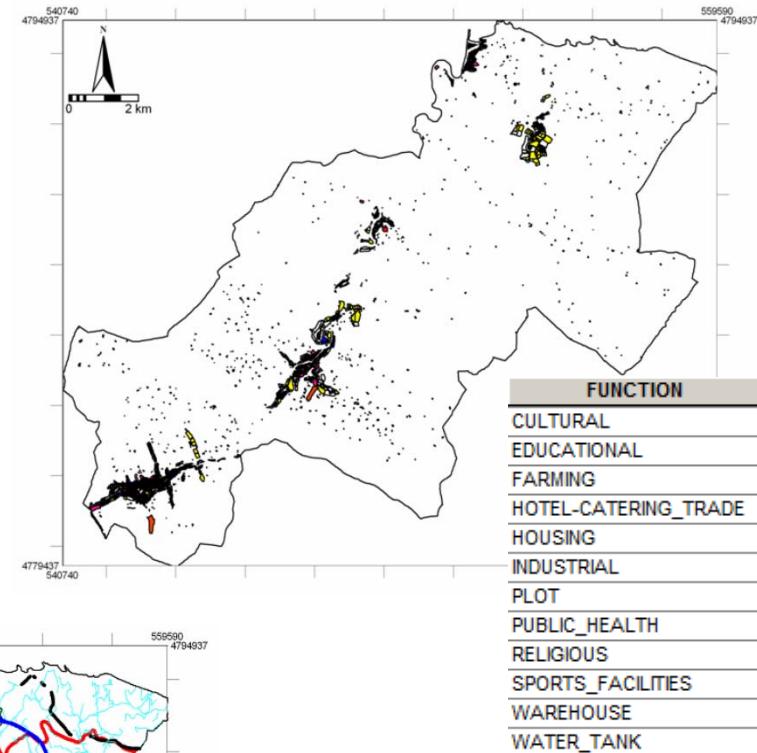
s2_fcs_precipitationsYearly_pun

4 Exposed elements

- ▶ Land use, buildings and transportation networks (road, railway)

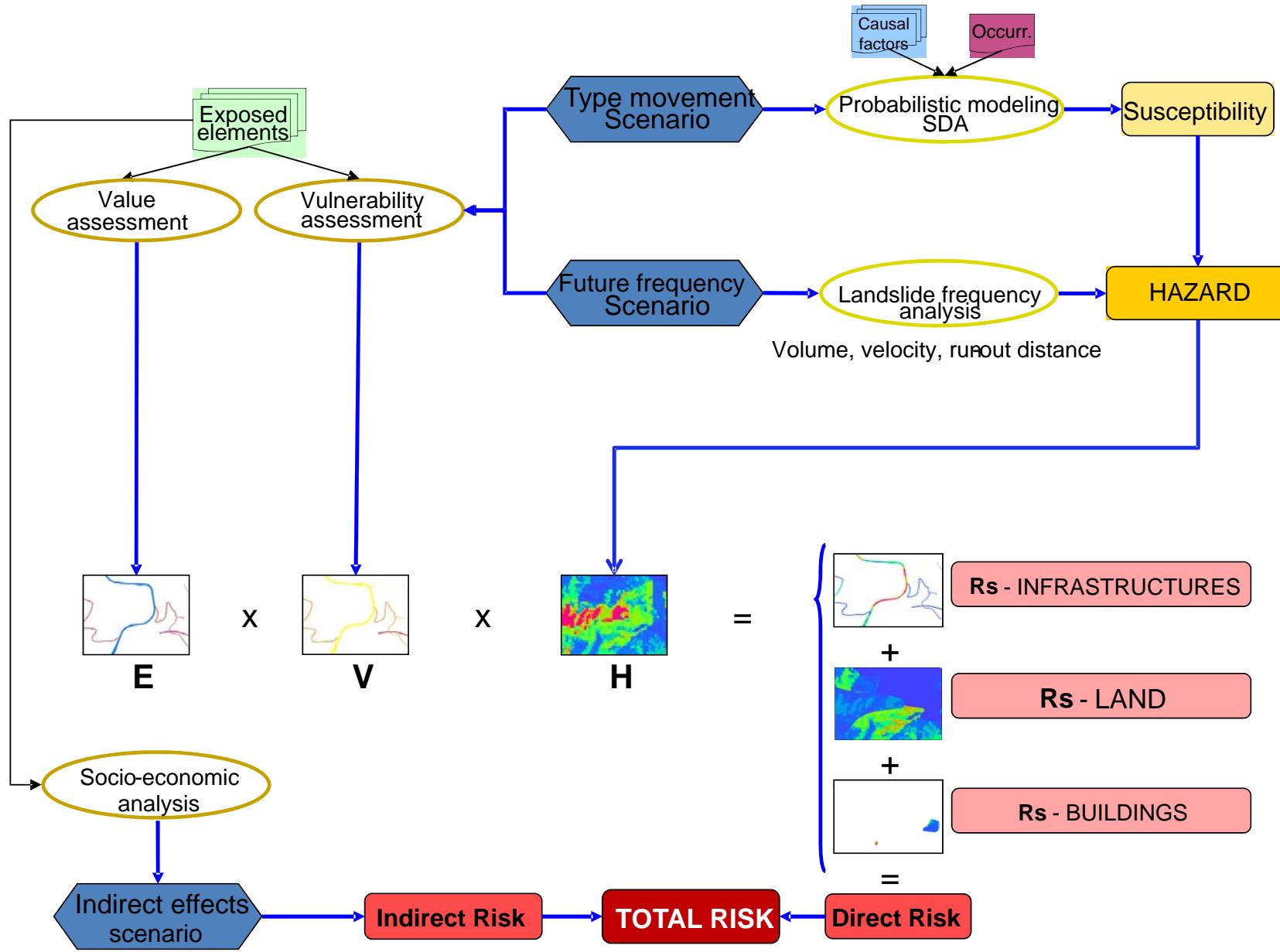


PRIMARY_USE	
Water	
Quarry	
Low forest	
Forest trees	
Fruit trees and vineyards	
Scrubland	
Pastureland	
Meadow	
Rocks	
Urban area	



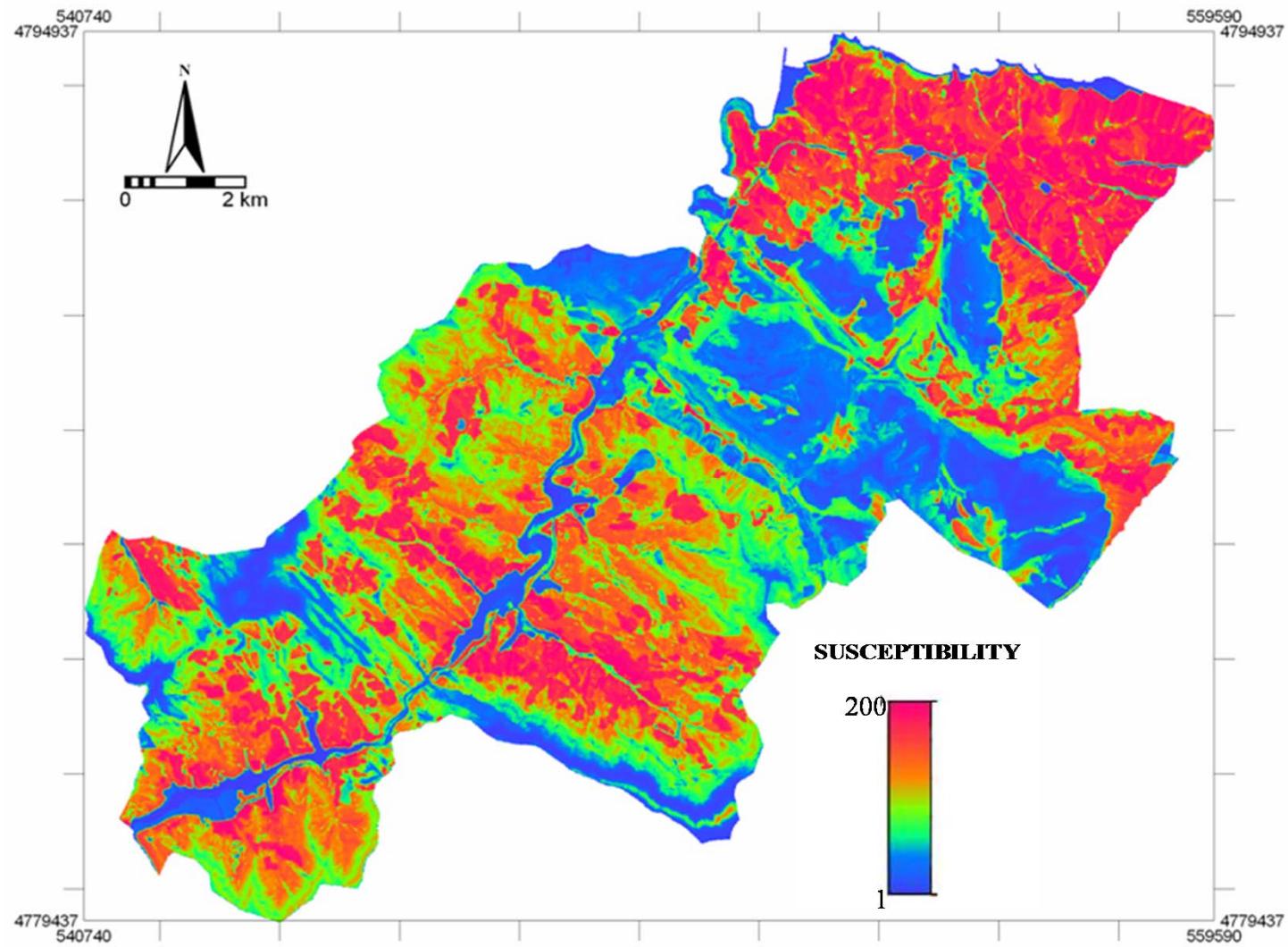
PRIMARY_CLASS	SECONDARY_CLASS	STRUCTURE
STATAL_ROAD	RED_ROJA	BRIDGE
STATAL_ROAD	RED_ROJA	NO_BRIDGE
REGIONAL_ROAD	RED_AMARILLA	BRIDGE
REGIONAL_ROAD	RED_AMARILLA	NO_BRIDGE
REGIONAL_ROAD	RED_NARANJA	BRIDGE
REGIONAL_ROAD	RED_NARANJA	NO_BRIDGE
REGIONAL_ROAD	RED_VERDE	BRIDGE
REGIONAL_ROAD	RED_VERDE	NO_BRIDGE
LOCAL_ROAD_PAV	RED_GRIS	BRIDGE
LOCAL_ROAD_PAV	RED_GRIS	NO_BRIDGE
LOCAL_ROAD_NOTPA	RED_GRIS1	BRIDGE
LOCAL_ROAD_NOTPA	RED_GRIS1	NO_BRIDGE

Reminder: scheme for estimate the landslides risk



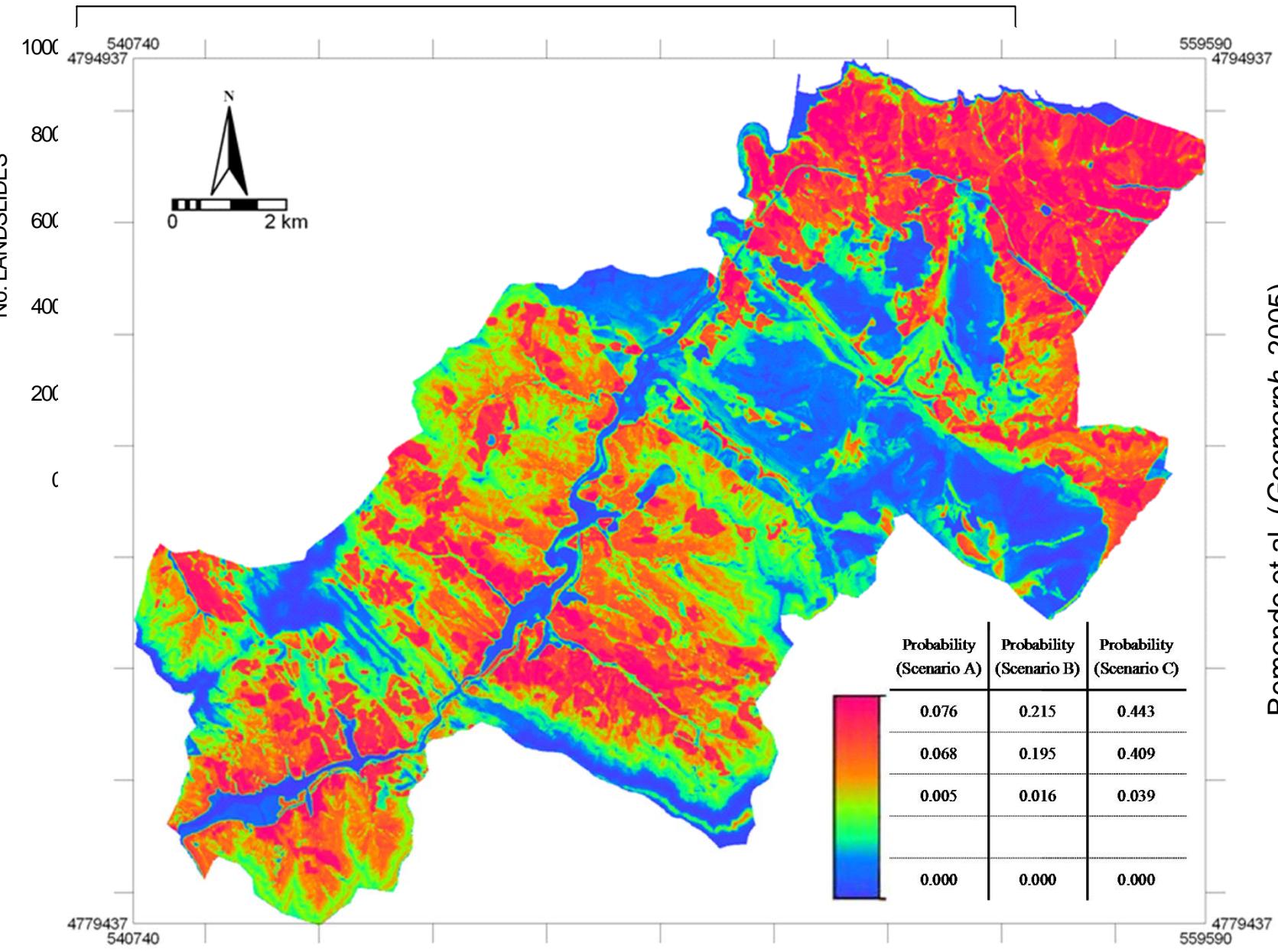
5 Susceptibility

Landslide susceptibility models can be obtained by means the statistical analysis between landslides occurred in the past and causal factors. Red: high susceptibility; Blue: low susceptibility.



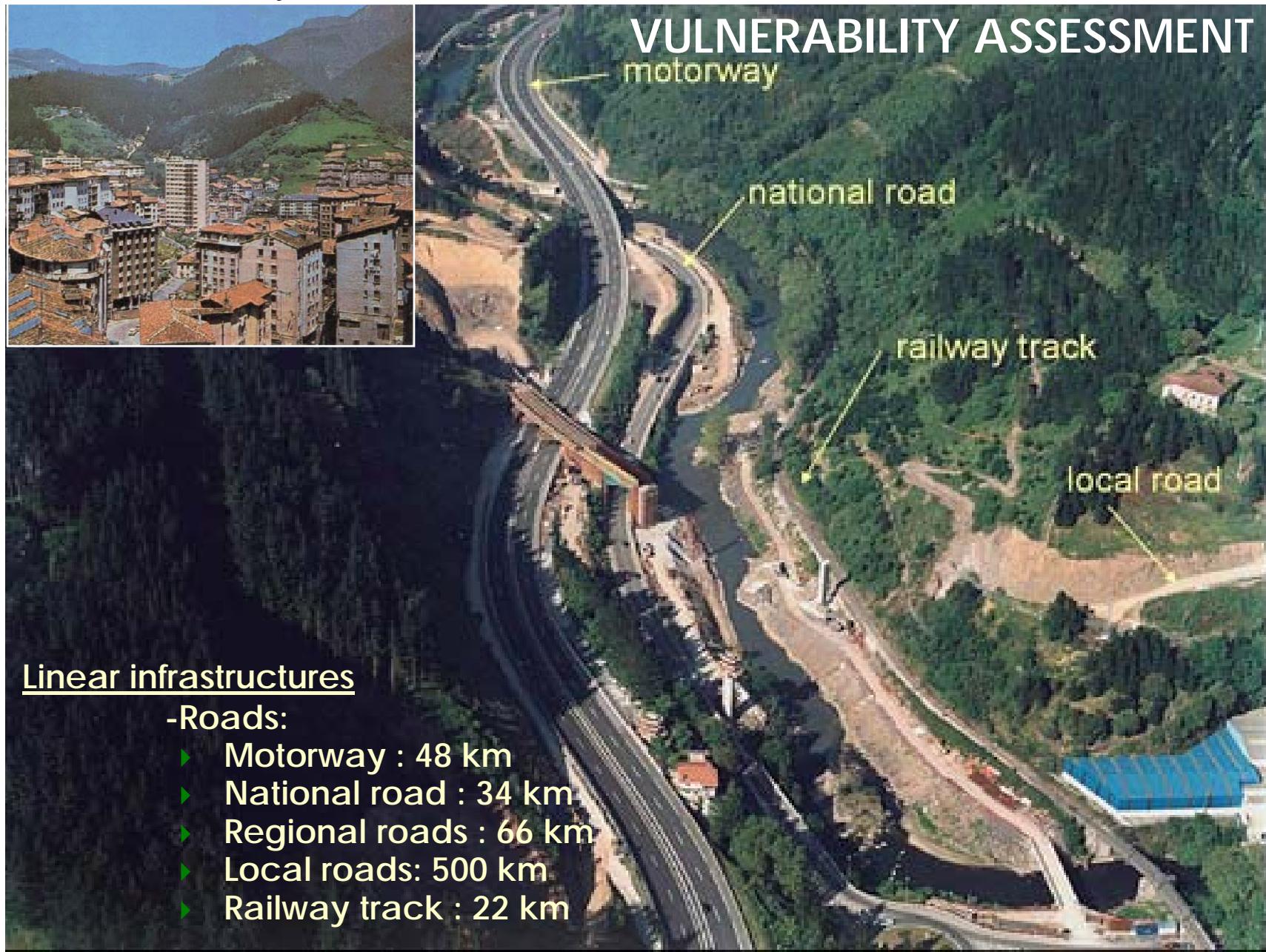
Remondo et al. (*Nat. Haz.*,2003a,b), Fabbri et al. (*Nat. Haz.*,2003),
Felicíssimo et al. (*Landslides*, 2013)

6 Hazard



Remondo et al. (*Geomorph.*, 2005),
Bonachea et al. (*Risk Anal.*, 2009), Bruschi (*Geomorph.*, 2013)

7 Vulnerability

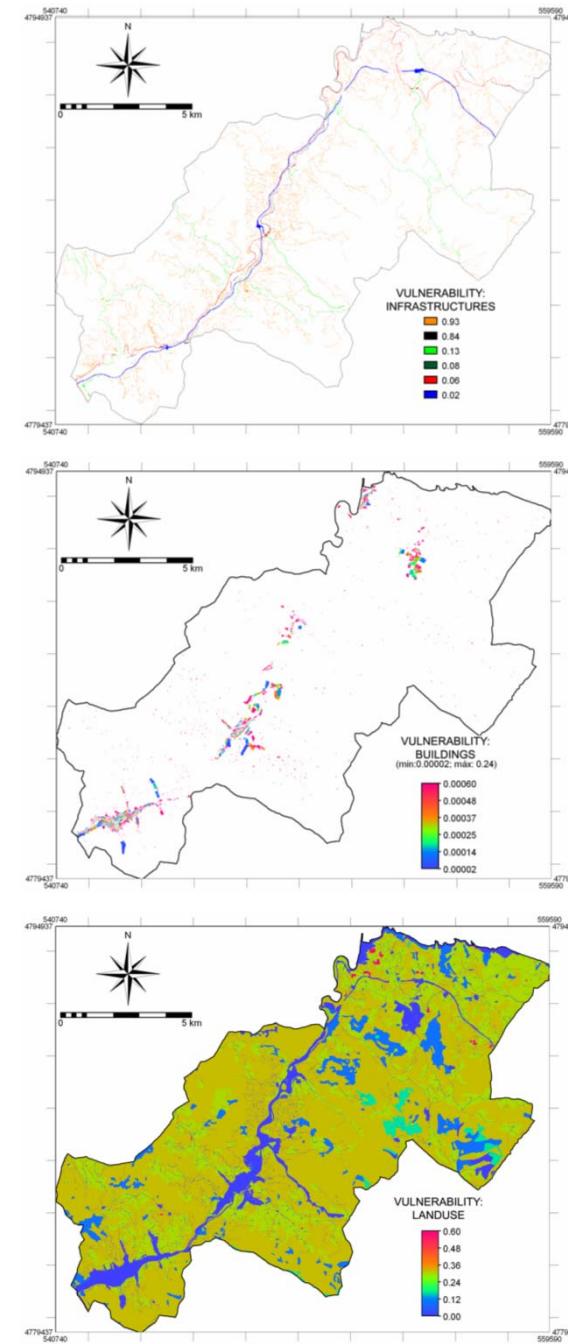


7 Vulnerability

Type	Value (€m)	Losses (€m)	Vulnerability (0-1)
Railway track	110	92.5	0.84
Local road	100	92.5	0.93
Regional road-B	700	92.5	0.13
Regional road-A	1200	92.5	0.08
National road	1500	92.5	0.06
Motorway	6000	92.5	0.02

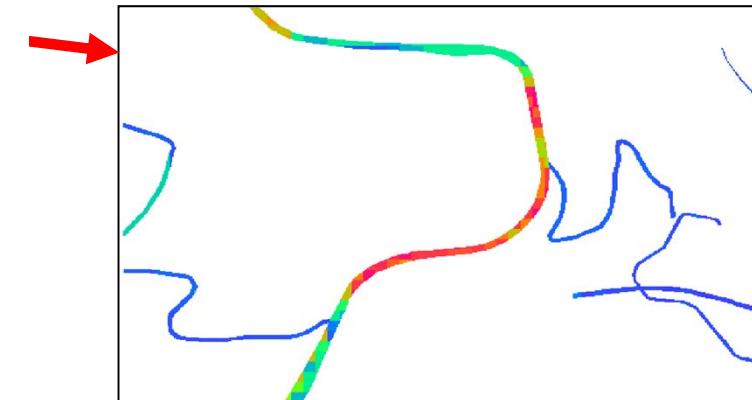
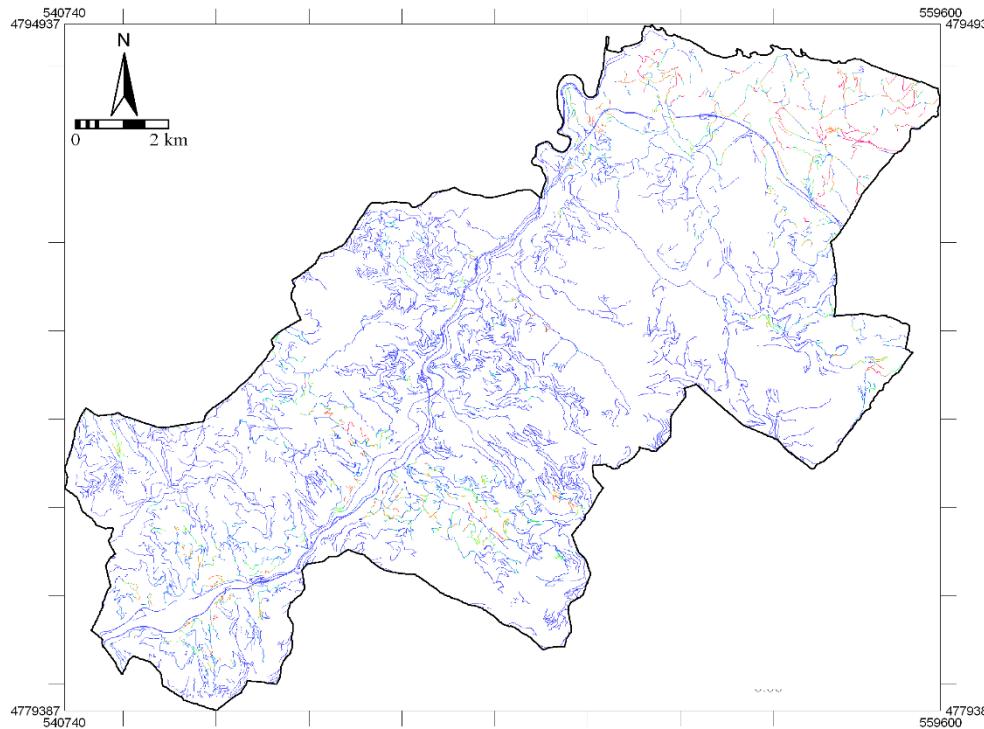
Building Id	Market value (€m ²)	Losses (€m ²)	Vulnerability (0-1)
1	57843.48	1162.50	0.02010
2	1186213.98	1162.50	0.00100
3	1225644.09	1162.50	0.00100
4	1399744.71	1162.50	0.00080
5	70377.48	1162.50	0.01650
6	968109.90	1162.50	0.00120
7	1961302.50	1162.50	0.00060
...
2805	106732.17	1162.50	0.01090

Land	Market value (€m ²)	Losses (€m ²)	Vulnerability (0-1)
Built-up area (unproductive)	-	-	-
Water (unproductive)	-	-	-
Rock (unproductive)	-	-	-
Grasslands	1	0.3	0.30
Pasturelands	0.6	0.1	0.17
Scrubland	0.1	0.01	0.10
Hawthorn land	0.1	0.01	0.10
Coniferous reforested	0.71	0.23	0.32
Cultivation: fruit tree	0.8	0.48	0.60



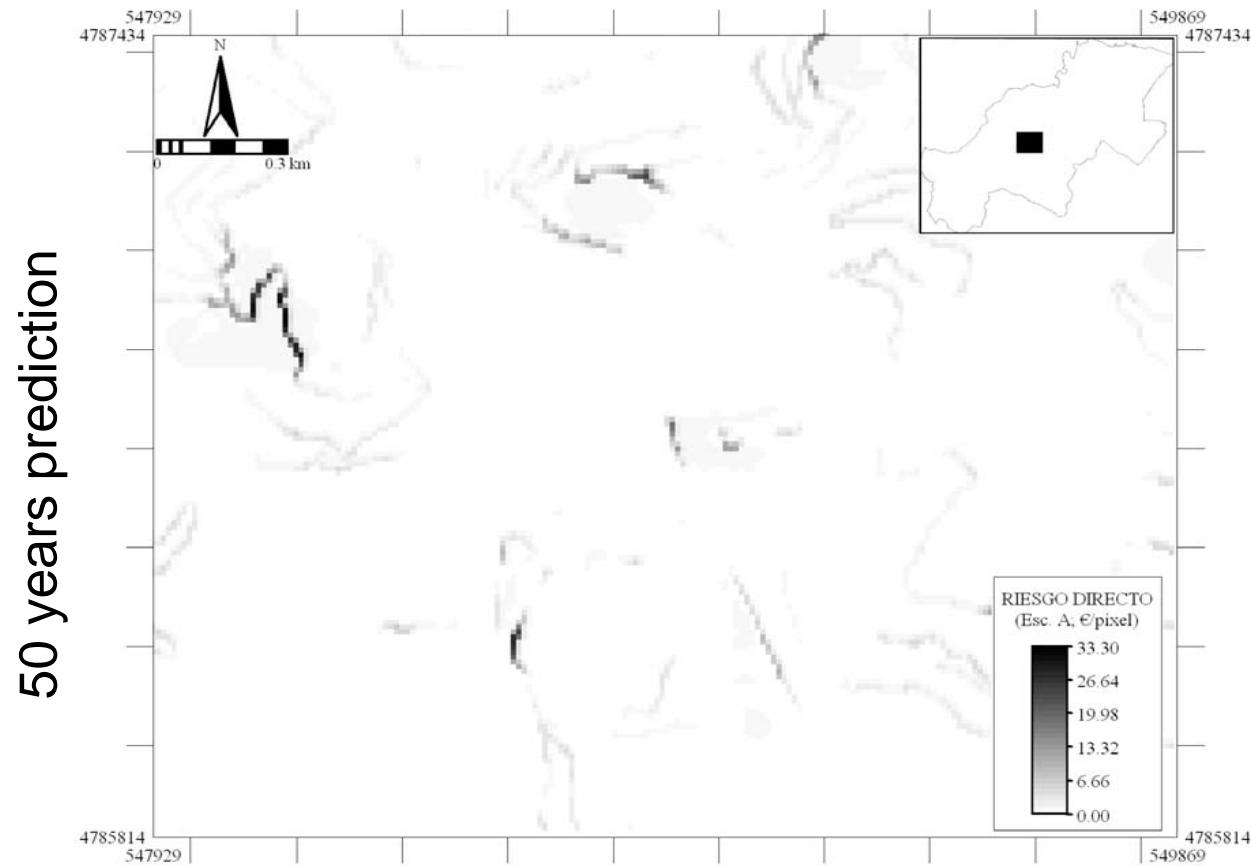
Fell et al. (Eng. Geol., 2008)
 Bonachea et al. (Risk Anal., 2009),

8 Risk. Specific for every exposed element. Ex: infrastructure



Infraestructure	50 years			10 years		
	Risk (€)	Risk (€)	Risk (€)	Risk (€)	Risk (€)	Risk (€)
	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
Railway track	133,921	387,456	835,210	27,348	64,734	79,845
<i>Local roads</i>	4,907,507	14,498,762	32,586,156	993,006	2,359,478	2,913,434
Regional roads	244,854	733,637	1,694,474	49,215	117,378	145,032
National road	268,972	784,626	1,718,908	54,798	129,700	160,093
Motorway	41,564	126,189	296,514	8,183	19,770	24,661
<i>Total</i>	5,596,818	16,530,670	37,131,262	1,132,550	2,544,864	3,323,065

8 Landslide direct Risk



Remondo et al. (*Geomorph.*, 2005, 2008),
 Bonachea et al. (*Risk Anal.*, 2009)

Specific risk	Risk (€)	Risk (€)	Risk (€)
	Scenario A	Scenario B	Scenario C
Infrastructure	5,596,818	16,530,670	37,131,262
Landuse	256,494	862,746	1,906,750
Buildings	7,851	23,304	52,809
<i>Direct risk (50 years)</i>	<i>5,861,163</i>	<i>17,416,720</i>	<i>39,090,821</i>
<i>Direct risk (10 years)</i>	<i>1,193,981</i>	<i>2,836,720</i>	<i>3,502,652</i>

Conclusions

- ▶ The use of a well structured geodatabase, and process automation, makes it possible the development and validation of numerous spatial models.
- ▶ Web map services (WMS and WFS) facilitate the external use and visualization and the dissemination of the results.
- ▶ Geodatabase constitute a sound basis for spatial data analysis for susceptibility, hazard, vulnerability and risk assessment and modelling in order to mitigate future damages, as illustrated in this presentation.
- ▶ Updated risk models are being developed and other specific cartographic tools are in progress in this project.

Thanks for your attention