



3rd OT-Med Progress Meeting - Aix-en-Provence, 7 jan. 2015

Assessment of susceptibility to seismic risk in Turkey



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FEARS project (2014-2016)

Frequency of large past earthquakes in the Aegean and associated risk susceptibility

Combining cosmogenic dating, historical data and spatial analysis

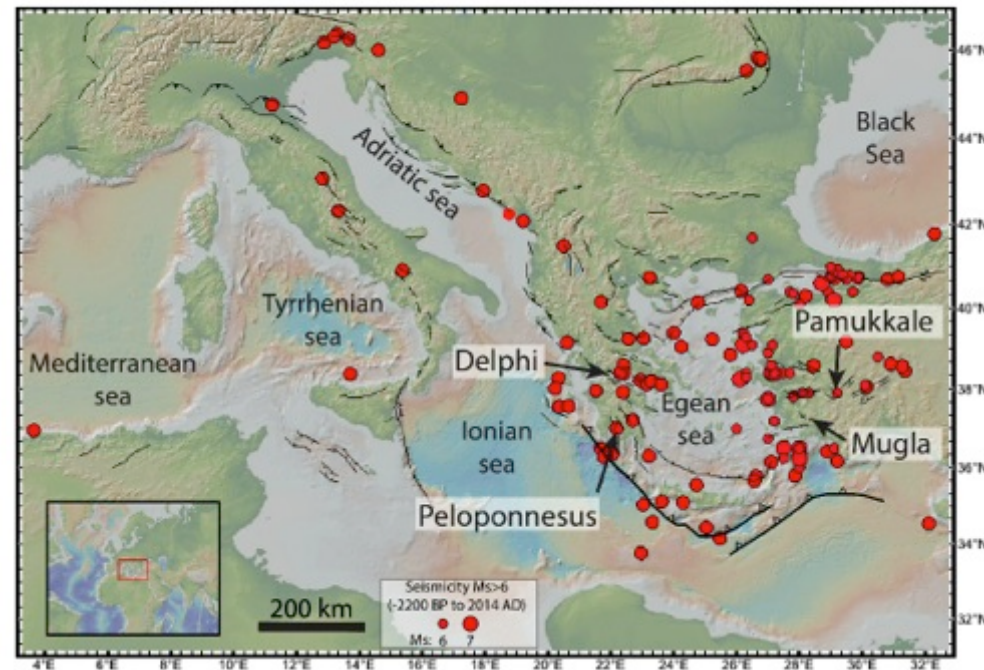
Project leaders : L. Benedetti (CEREGE) + S. Robert (ESPACE)

Objective:

Provide improved metrics of seismic risk exposure and define how future earthquakes might affect the socio-economic development of the region

Aegean

- high level of seismic hazard
- numerous World Heritage sites
- fast growing regions (coastal tourism and real estate developments)

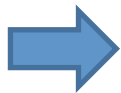


Rationale of the study

1. Each territory is a system which integrity/functioning can be disturbed by earthquakes

2. Earthquakes are very difficult to predict. But, given a fault system, it seems they have a frequency over long periods of time

3. Places strongly affected by earthquakes in history will face other earthquakes in the future



Given a territory, mapping past earthquakes described in catalogues and/or identified from paleosismology and spatialising the socio-economic stakes is a way to:

- highlight areas the most at risk today
- help decision makers in their spatial planning practices

Objective: Design of a methodology of seismic risk assessment based on **historical seismicity** and the **present territorial vulnerability**



Susceptibility: predisposition of elements/conditions (natural and social) to create risk potentiality

Area of study

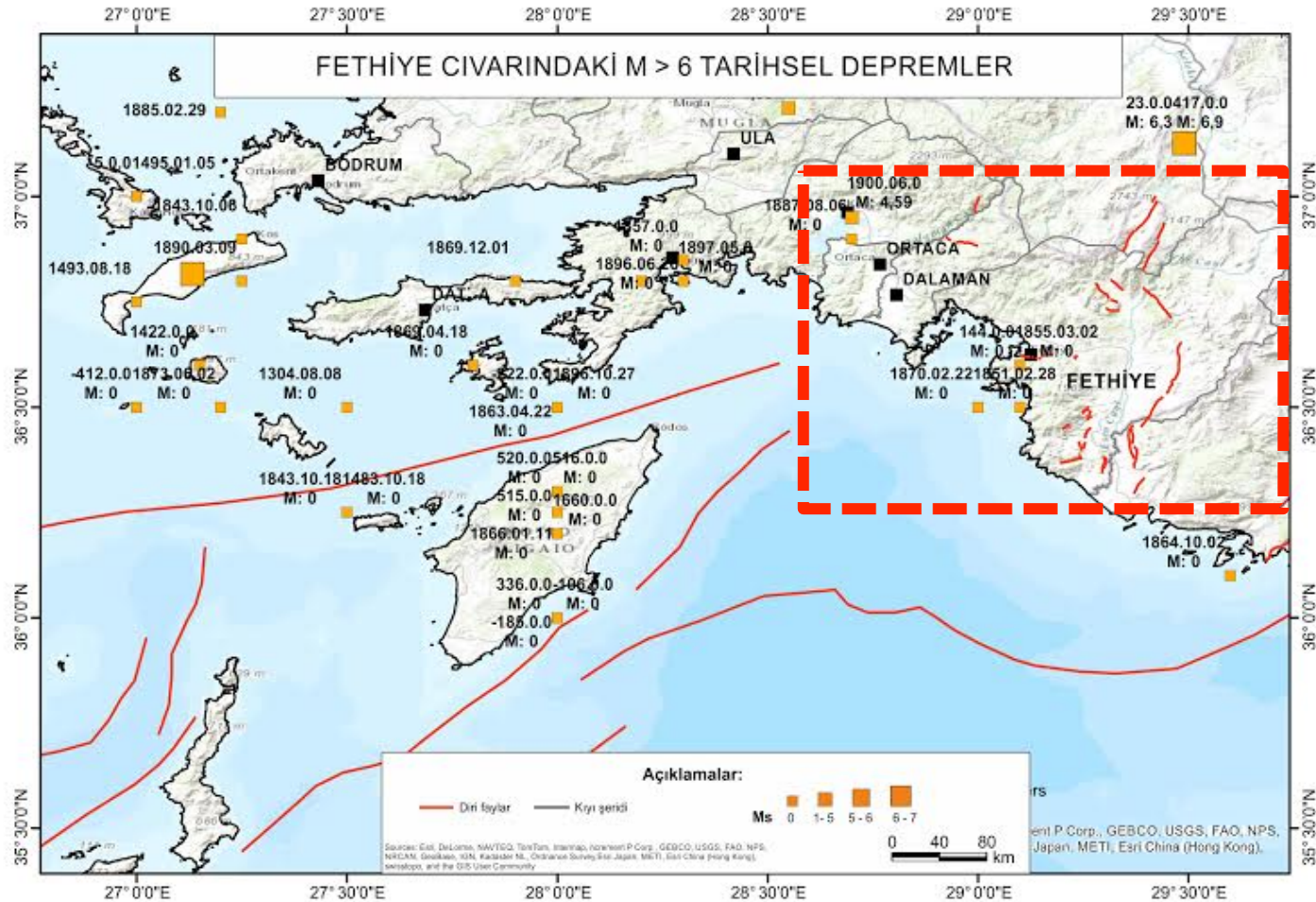
Muğla province, Turkey

Many strong earthquakes in the recent past : 1851, 1856 (intensity 9–10), 1957 (Mw 7.1)



Area of study

Existing hazard map to address risk prevention (AFAD)



Unsuitable for spatial planning

Area of study

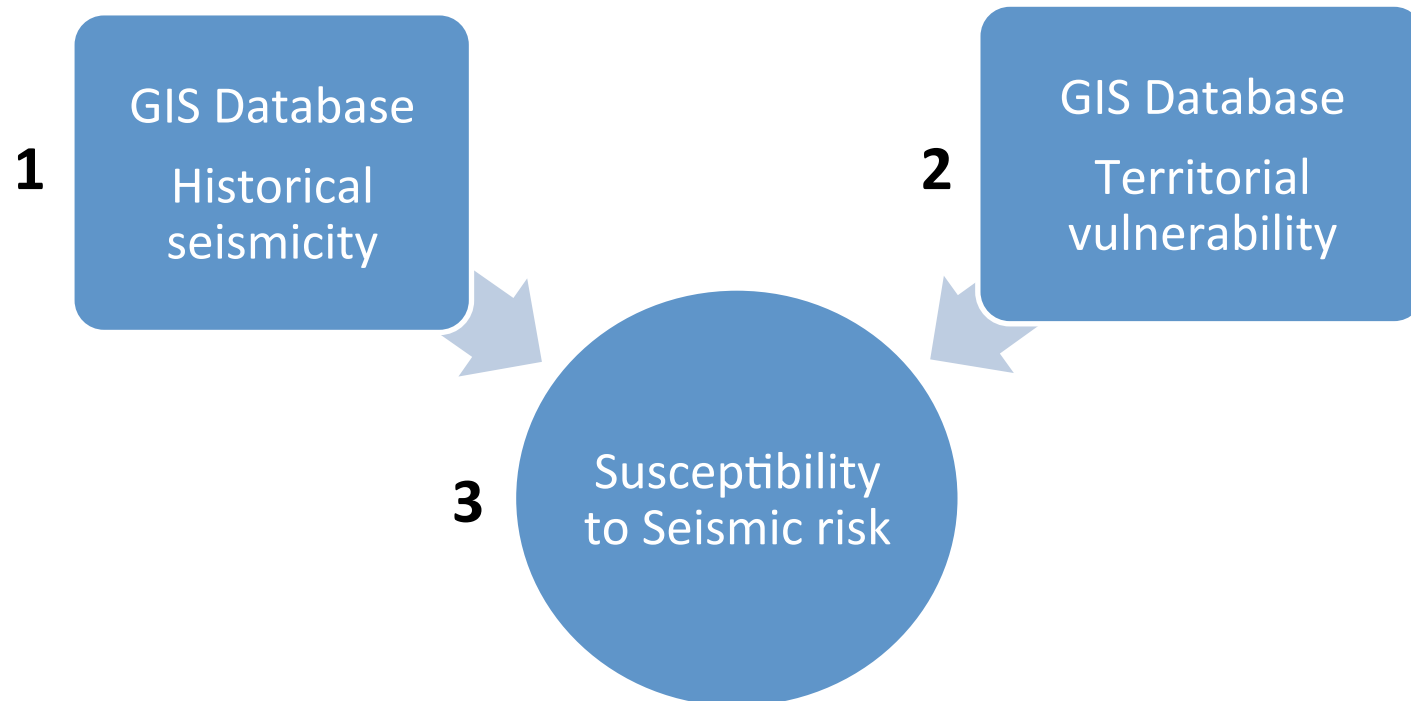
Famous riviera



Methodology

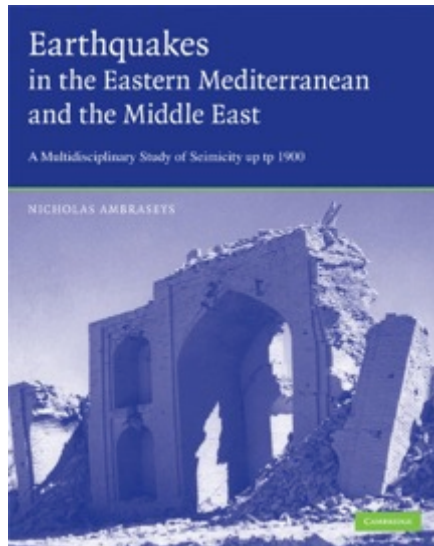
Holistic assessment process based on a geographical approach

Field work + social and cultural approach + data collection and critical analysis + spatial analysis



Historic seismicity assessment

1- Historic seismicity assessment



Ambraseys catalog : the most complete inventory of past earthquakes in the Mediterranean from 2100 BC to 1900 AD

AD 1851 Apr 3 Fetiye

This was the largest shock of the series which began on 28 February in Makri. It occurred at 16 h 30 m and **was very widely felt.**

Levisi on the mainland was totally destroyed, and in Makri the sea rose well above its normal level, flooding the coast permanently, but causing no damage.

Further inland the shock triggered new landslides and rock falls and in places the ground opened up. Smoke (dust?) was seen rising from the mountains.

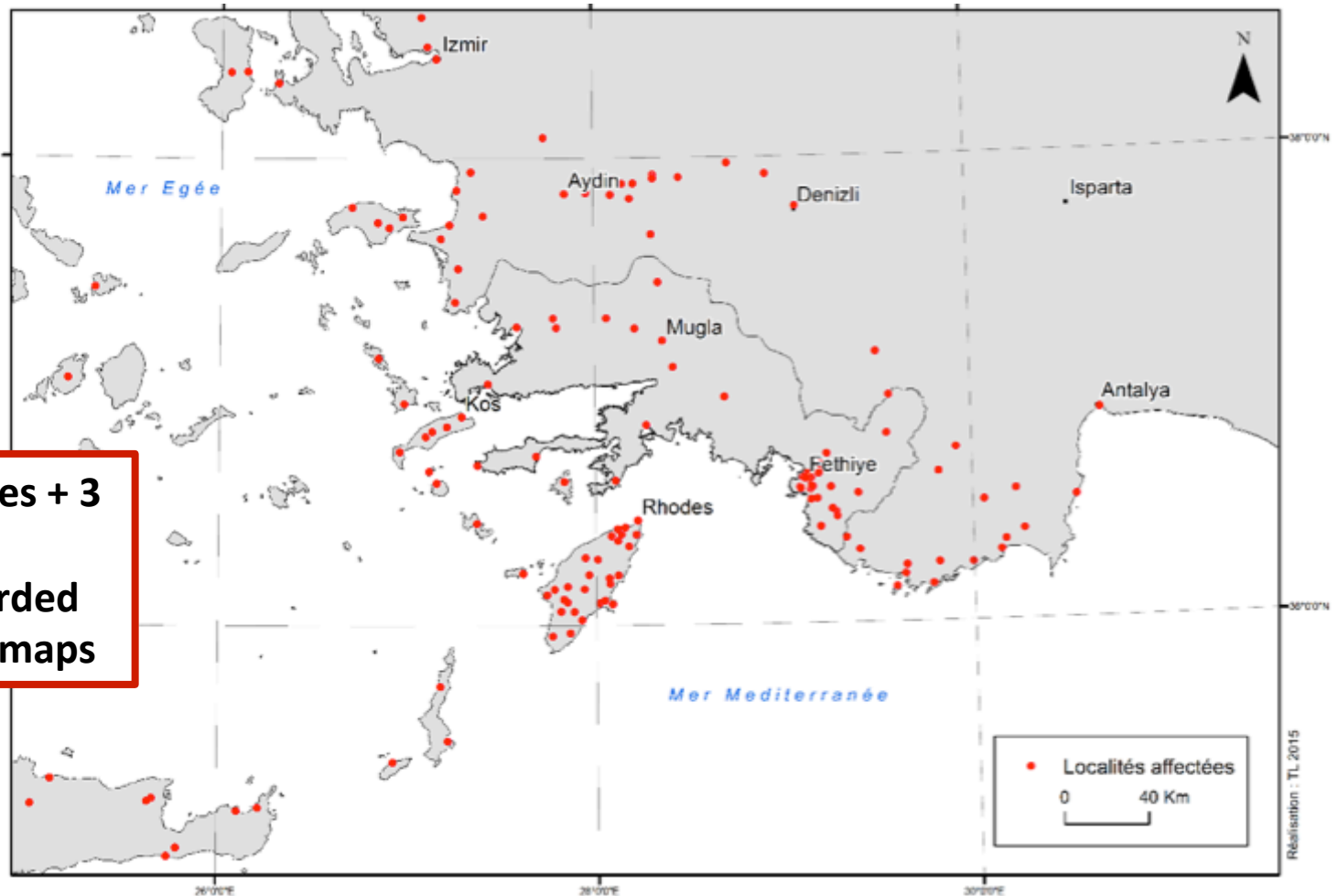
In Rhodes the shock was very strong but caused no damage. It was felt slightly in Crete and Cairo, but not in Thebes. Shocks continued for a short while, no more than a few hours (Perrey 1852, 361–362; BBA IMV 6790, 29 March O.S. 1267 (1851)).

GIS database
of historical
seismicity in
Mugla
Province

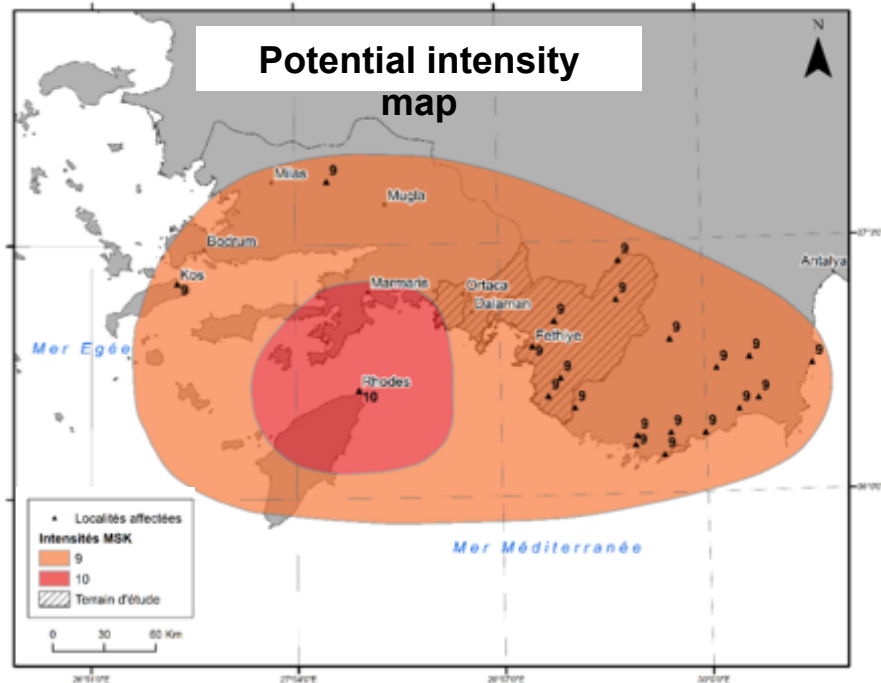
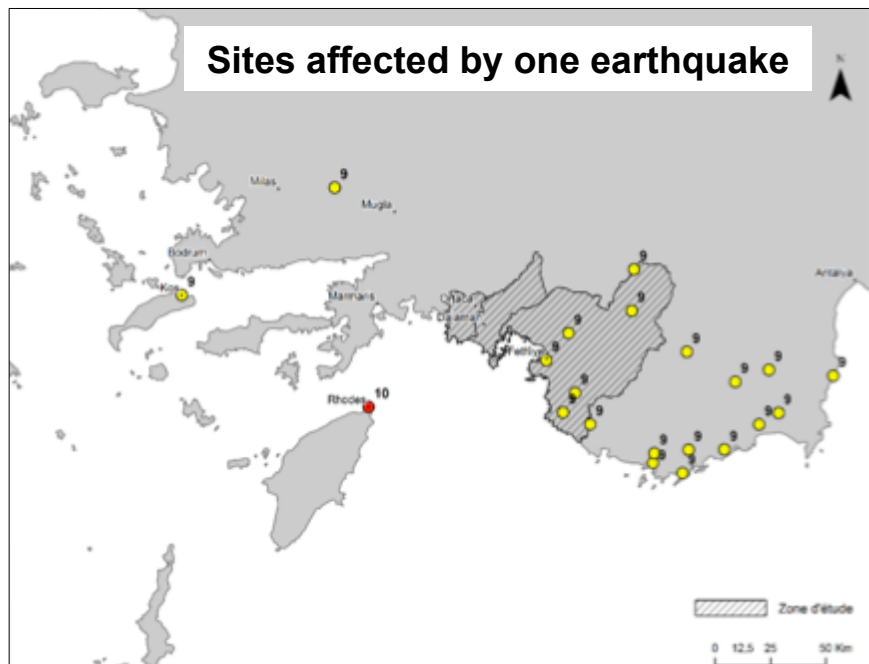
MSK intensity

Historical seismicity assessment

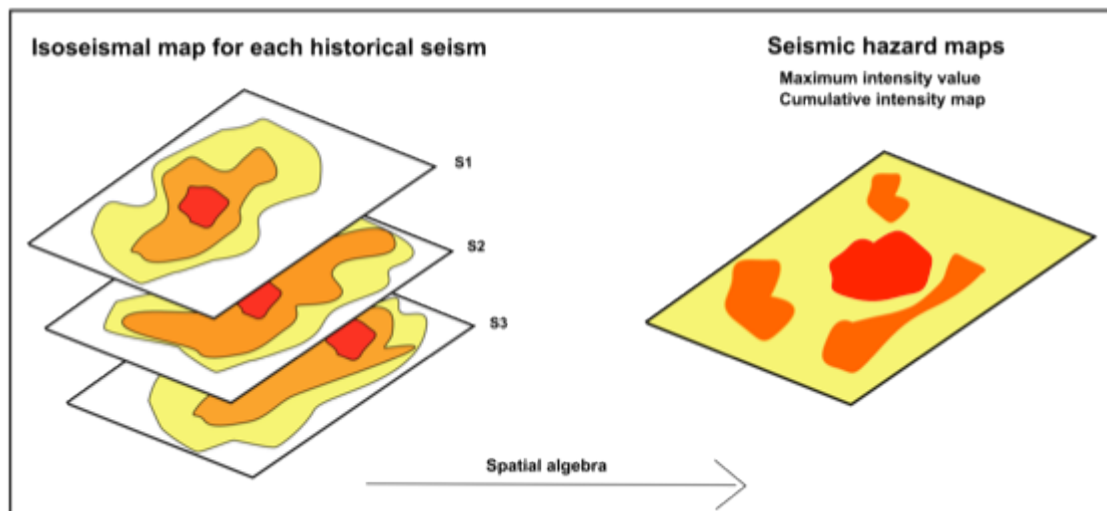
Places affected by destructive earthquakes in history (between 2100 BC and 1900)



Historical seismicity assessment

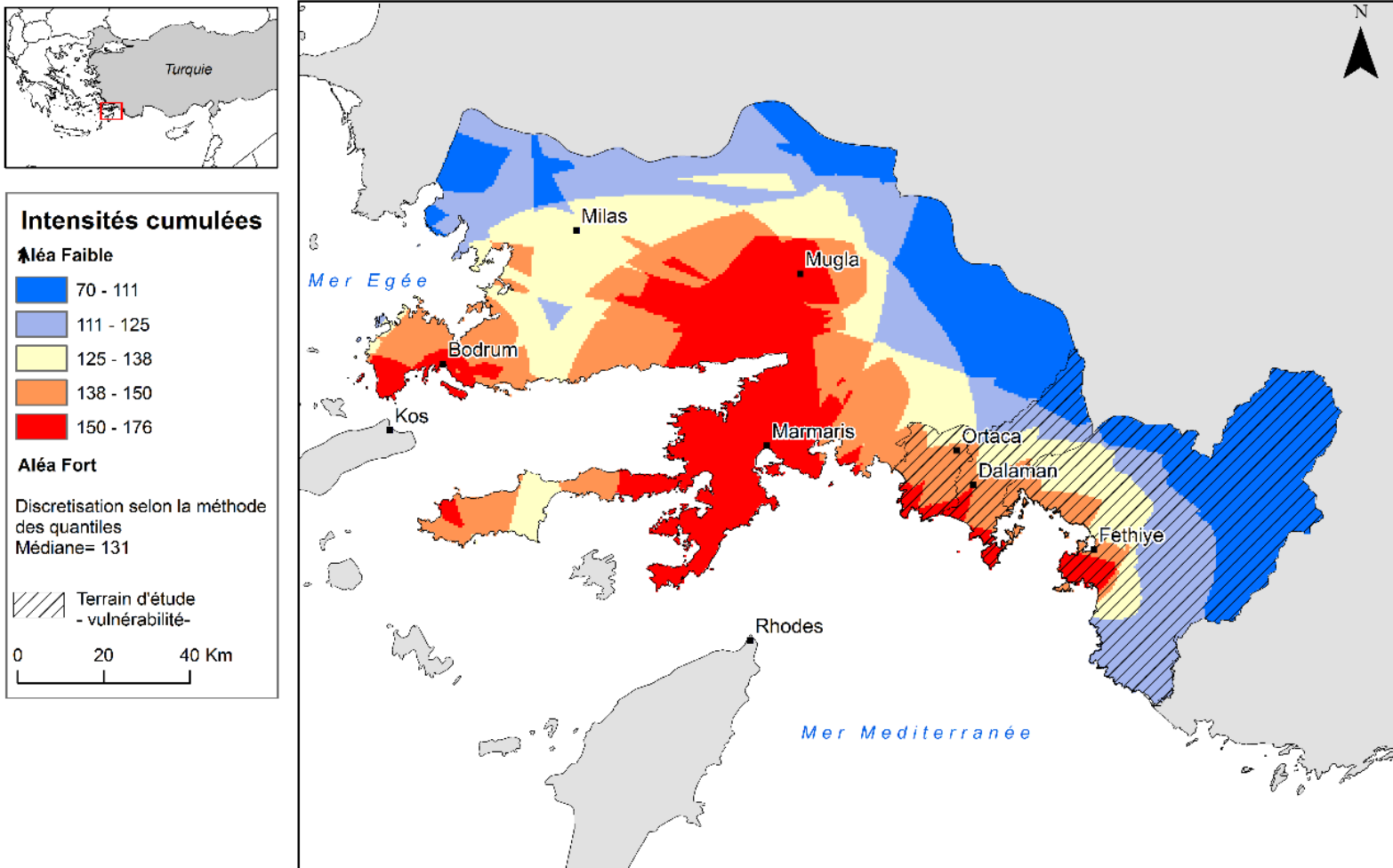


Isoseismal maps



Historical seismicity assessment

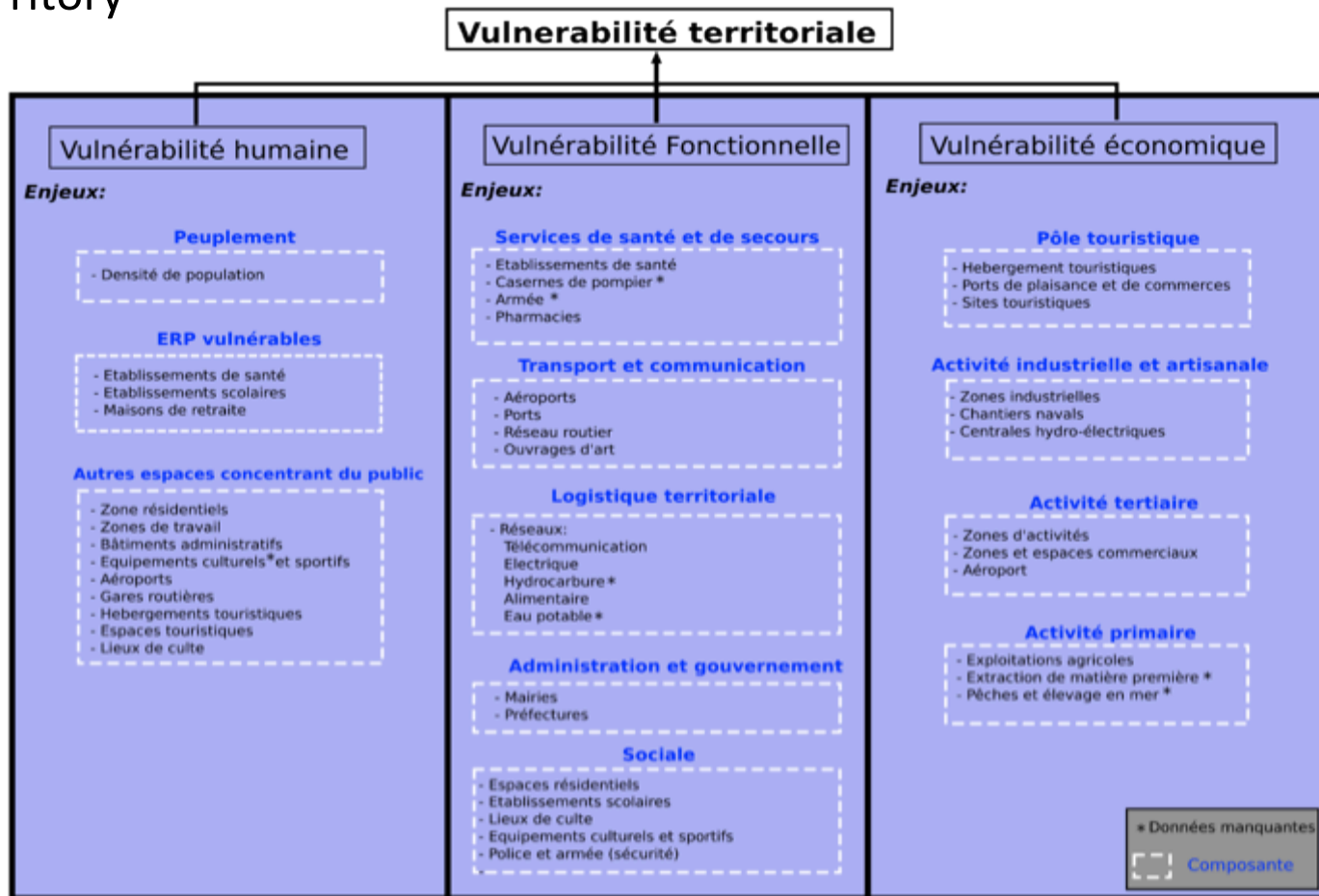
Cumulated intensity (MSK scale) recorded in history



Territorial vulnerability assessment

2- Territorial vulnerability assessment

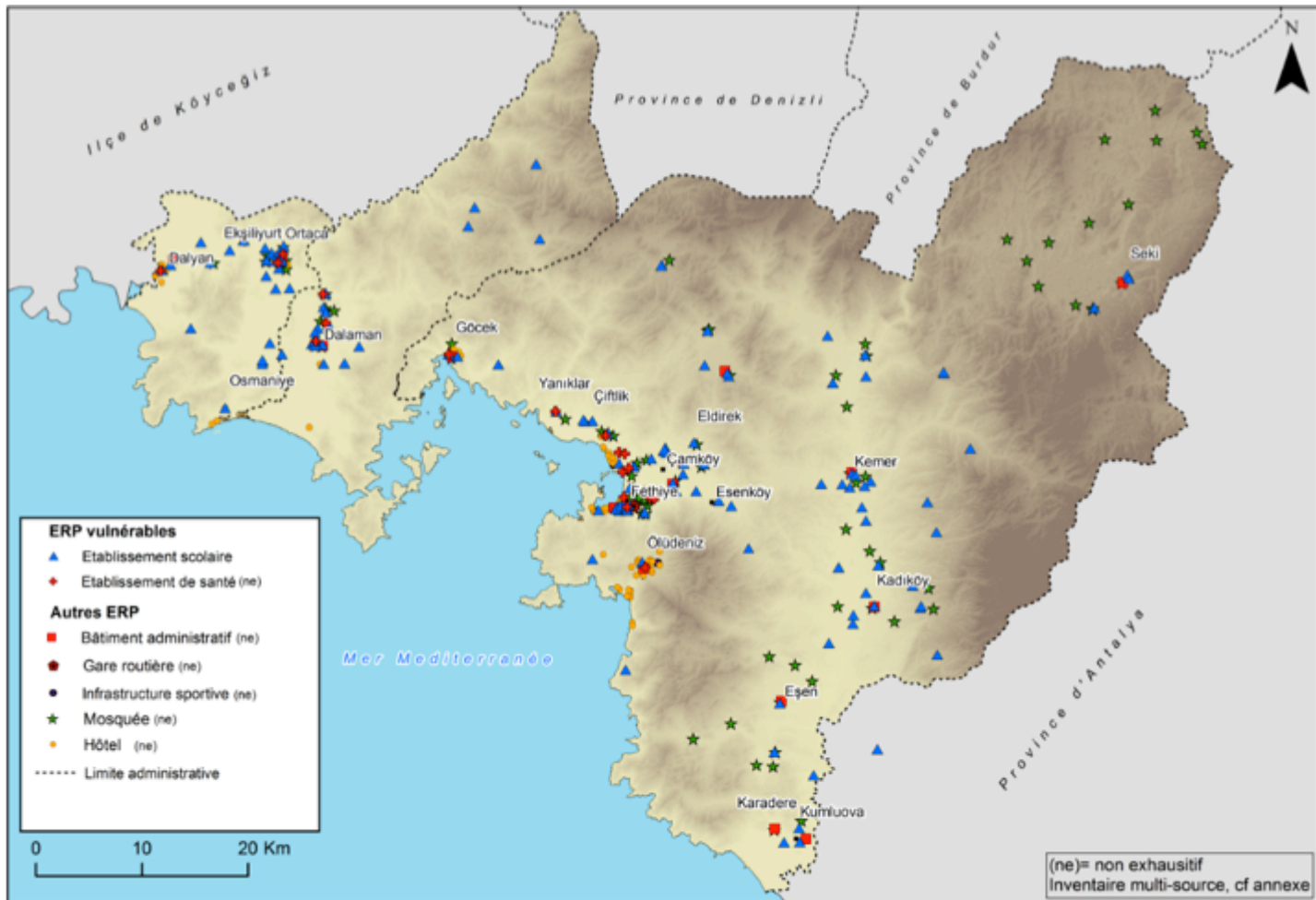
Listing and mapping of the major stakes characterizing the vulnerability of the territory



Territorial vulnerability assessment

Data gathering, georeferencing and mapping

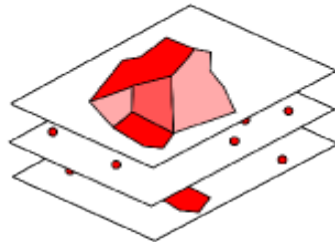
Human vulnerability : public equipments receiving people



Territorial vulnerability assessment

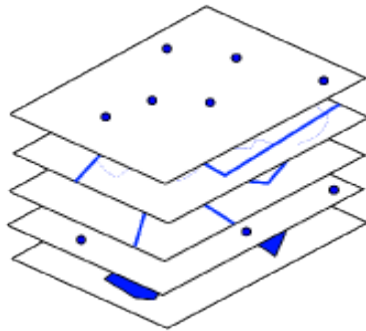
Multi-Criteria Analysis + spatial analysis

Vulnérabilité humaine



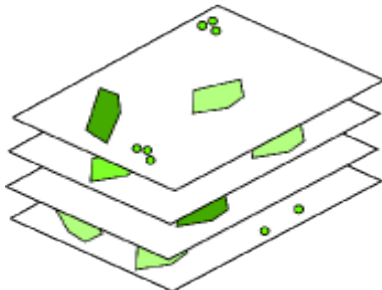
Densité de population
ERP vulnérables
Autres espaces concentrant
du public

Vulnérabilité Fonctionnelle



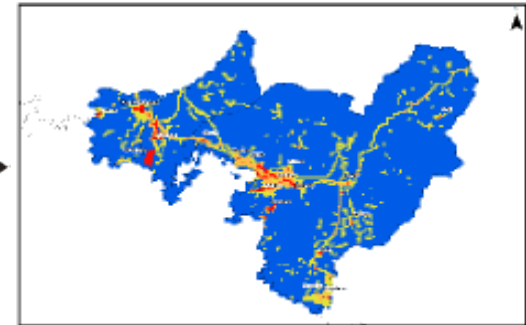
Services de santé et de secours
Transport et communication
Logistique territoriale
Administration et gouvernement
Sociale

Vulnérabilité économique



Pôle touristique
Activité industrielle et artisanale
Activité tertiaire
Activité primaire

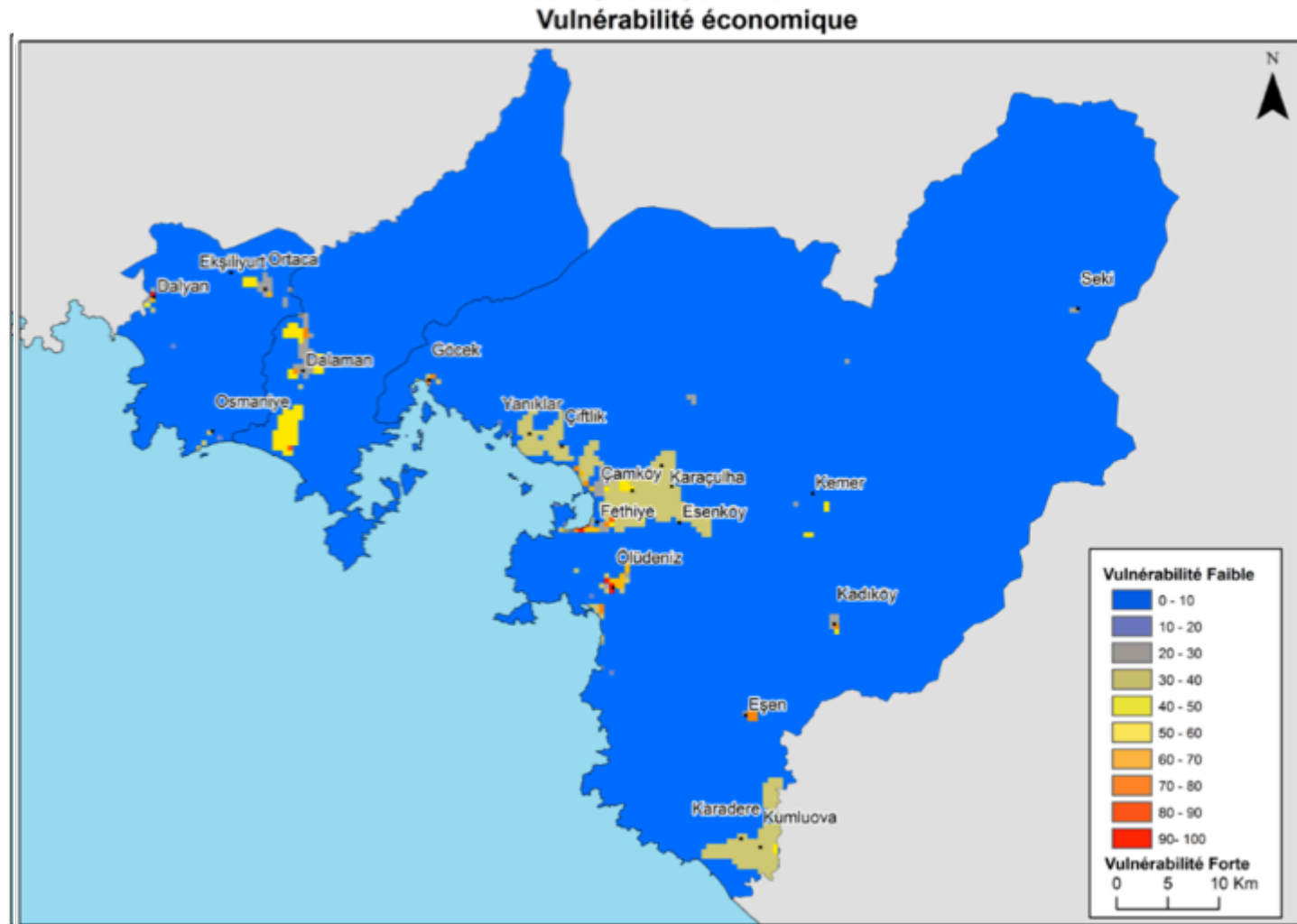
Vulnérabilité territoriale



Cell size : 500 m

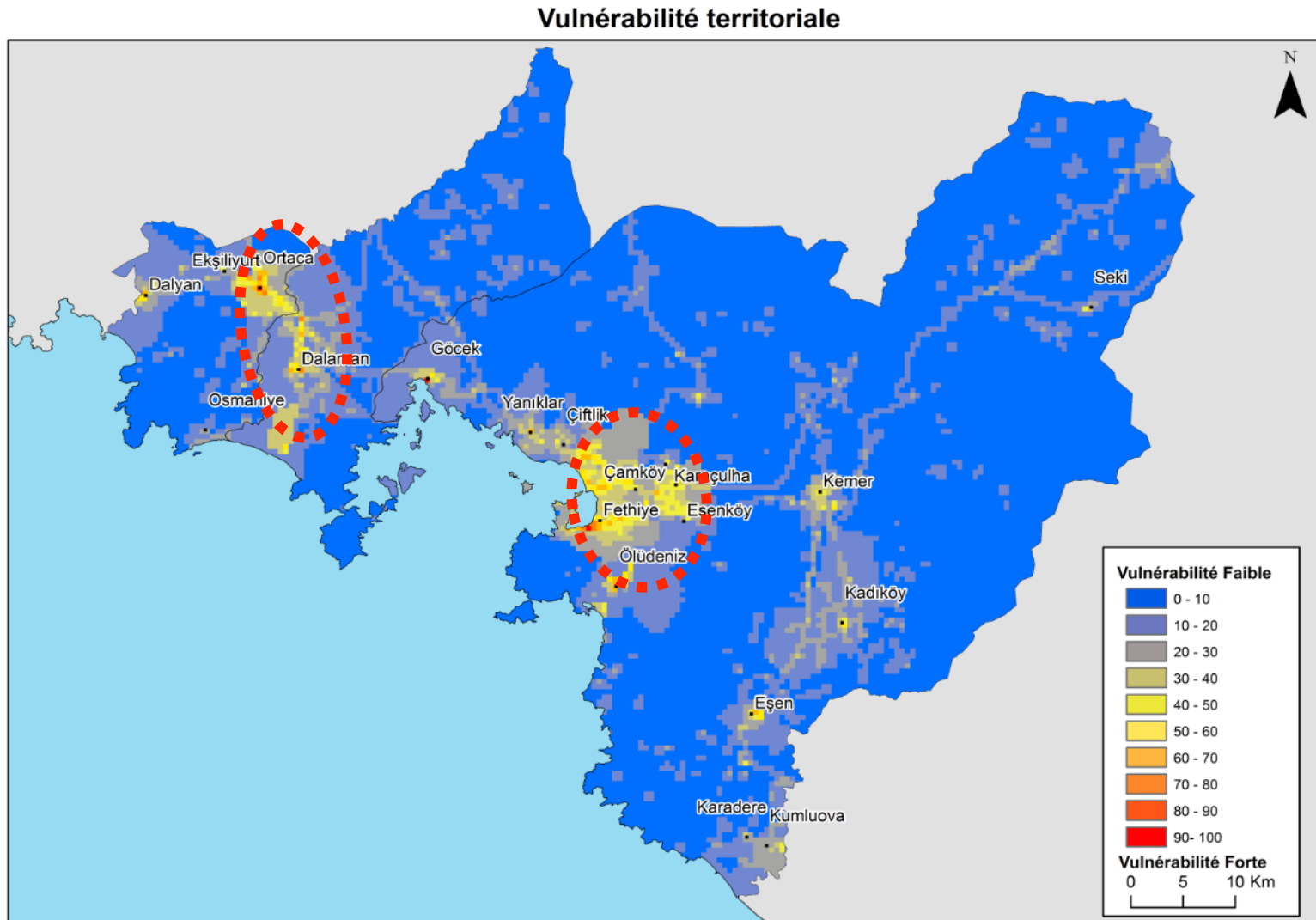
Territorial vulnerability assessment

Human, functional and economic vulnerability maps



Territorial vulnerability assessment

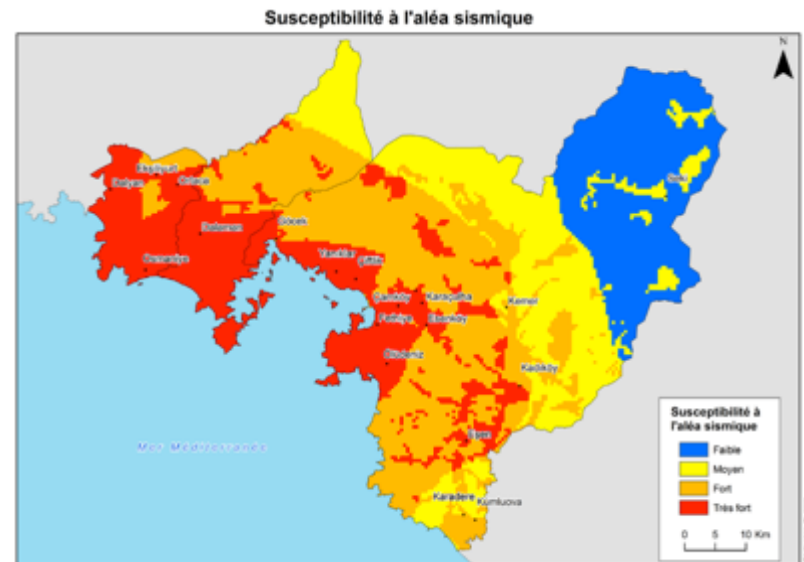
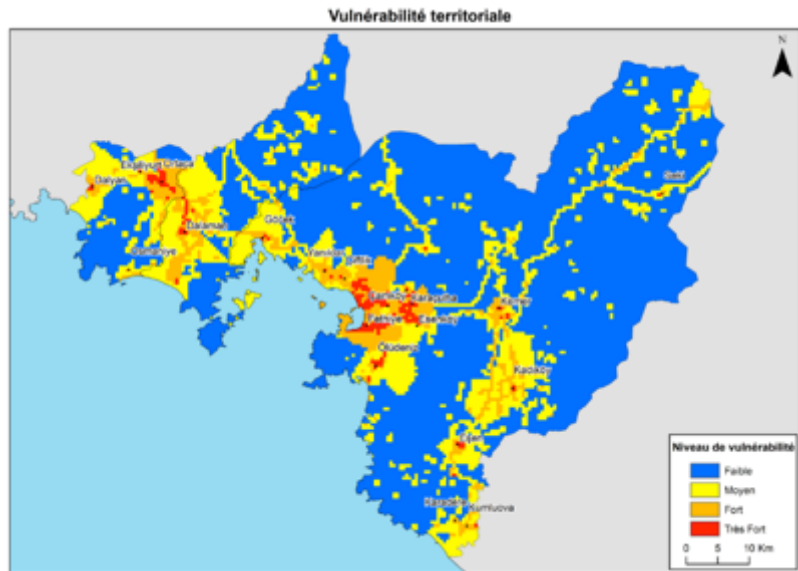
Territorial vulnerability map



Risk assessment and planning recommendations

3- Risk assessment and planning recommendations

Combining historic seismicity and present vulnerability (data recoding)



4 levels of territorial vulnerability

4 levels of past seismic intensity



Areas most at risk
Areas most suitable for future development

Risk assessment and planning recommendations

Combining historic seismicity and present vulnerability

Decision matrix → 7 levels of risk susceptibility

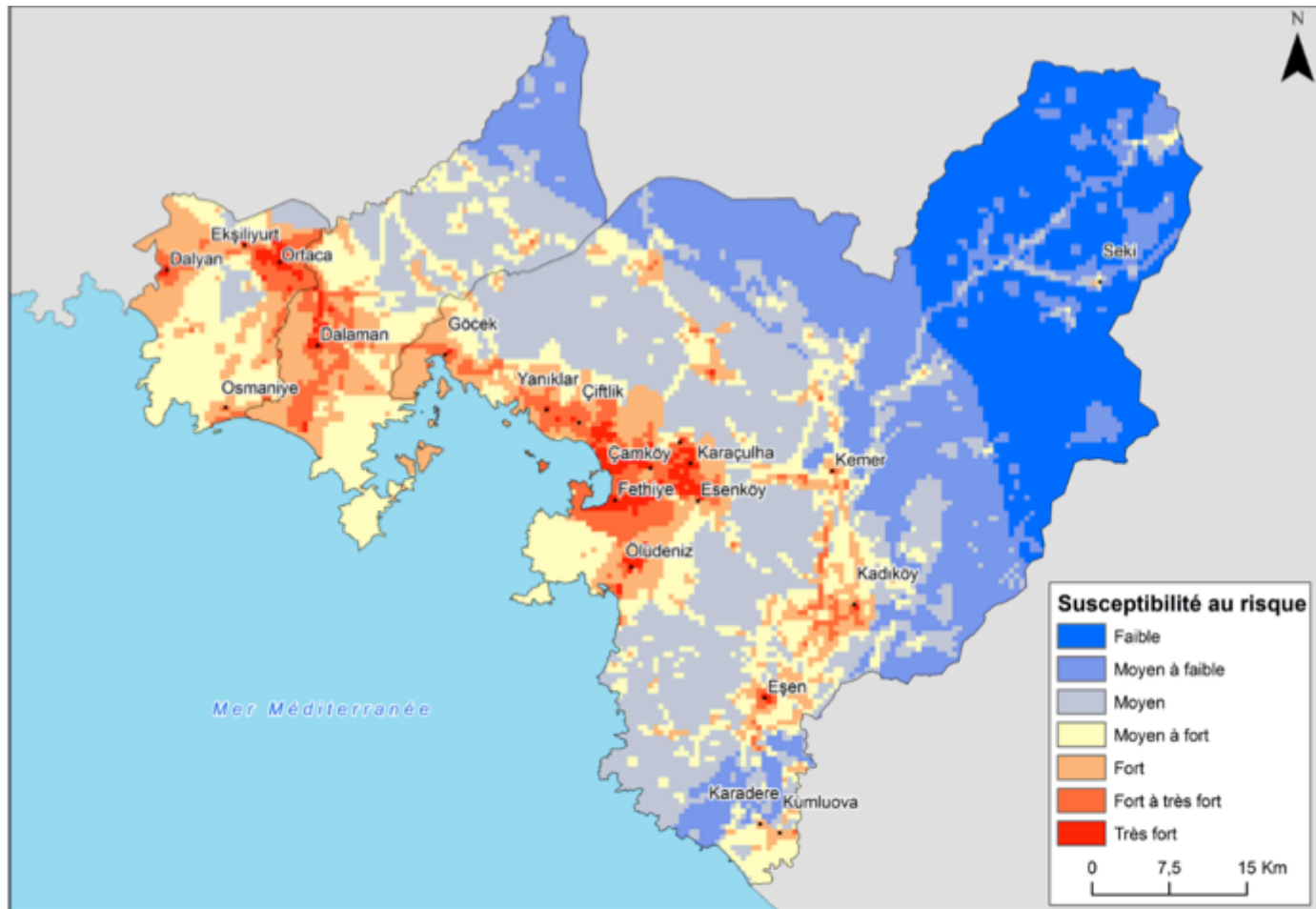
- Past seismic intensity +

| | Risque (aléa & vulnérabilité) | Aléa Faible | Aléa Moyen | Aléa Fort | Aléa Très Fort |
|---------------|-------------------------------|----------------|----------------|------------------|------------------|
| - | | | | | |
| Vulnerability | Vulnérabilité Faible | Faible | Faible à moyen | Moyen | Moyen à fort |
| | Vulnérabilité Moyenne | Faible à moyen | Moyen | Moyen à fort | Fort |
| | Vulnérabilité Forte | Moyen | Moyen à fort | Fort | Fort à très fort |
| + | Vulnérabilité Très Forte | Moyen à fort | Fort | Fort à très fort | Très Fort |

From (Gleyze, 2002 ; Beck, 2006)

Risk assessment and planning recommendations

Final output: areas the most susceptible to seismic risk



Opportunities ?
Constraints ?
... in terms of
planning



Susceptibility Map = unique of this kind

Conclusion

- Assessing and mapping seismic risk based on past seismic data and today's vulnerability is possible**
- Coastal areas in Mugla province are definitely at risk**

Next steps...

Validation of the methodology through the building of other scenarios + application to another study area + integration of paleoseismic data

Local authorities and local stakeholders understanding of the susceptibility maps must be assessed

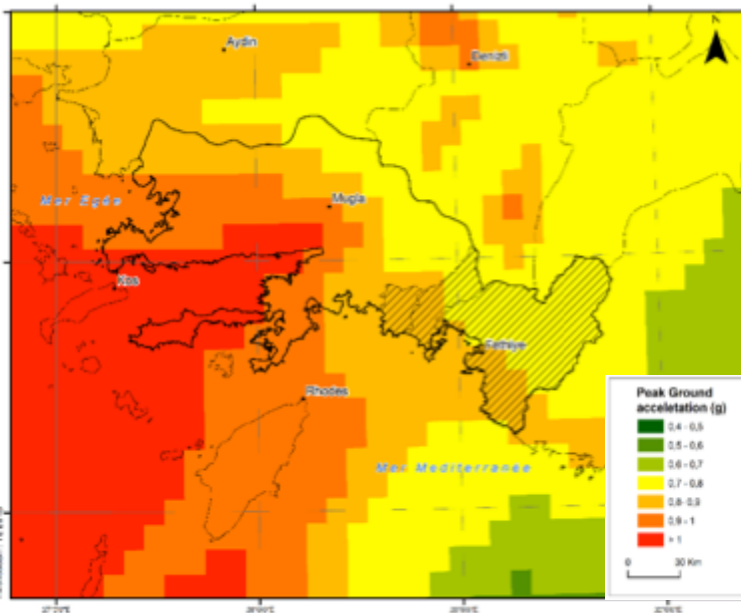
Seismic risk memory could be integrated into the methodology

Risk perception through this methodology must be assessed

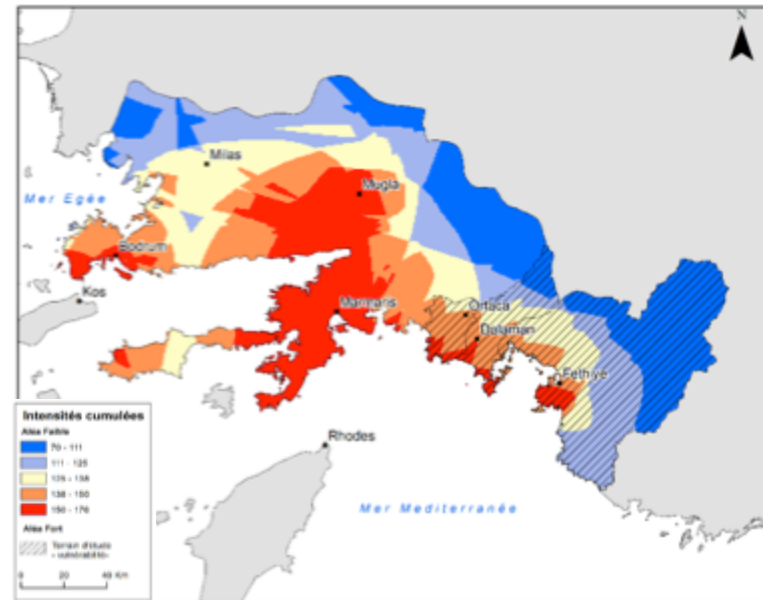
**Thank you for your
attention**

Discussions

Comparaison des méthodes de caractérisation de l'aléa sismique



Carte probabiliste de l'aléa sismique: accélération au sol prévu pour une période de retour 2475 ans. Projet SHARE 2013



Susceptibilité à l'aléa sismique d'après la sismicité historique

MCA - scoring

| Degré de vulnérabilité / Classes | Densité (hab/km ²) | Etablissement recevant du public vulnérable (nombre par maille) | Autres espaces concentrant du public (nombre par maille) |
|----------------------------------|--------------------------------|---|--|
| Nul : 0 | | 0 | 0 |
| Faible : 0,25 | 0 – 75 | 1 | 1 |
| Moyen : 0,5 | 75 – 400 | 2 – 3 | 2 – 3 |
| Important : 1 | 400 et plus | Plus de 3 | Plus de 3 |

| Degré de vulnérabilité / Classes | Réseau de transport | Fonctions Sociales (nombre d'établissement par maille) | Service de santé | Logistique territoriale | Administration et gouvernement (Nombre d'habitant qu'administre le bâtiment) |
|----------------------------------|---|--|------------------------------------|---|--|
| Nul : 0 | Aucun réseau | 0 | Aucun établissement | Aucun enjeu | Pas d'administration |
| Faible : 0,25 | -Route communale -Port | 1 | -Pharmacie, -Maison de retraite | / | 0 – 3000 |
| Moyen : 0,5 | -Route Provinciale -Gare routière | 2 et 3 | / | -Relais télécommunication -Centre commerciaux - Station épuration | 3000 – 10 000 |
| Important : 1 | -Aéroport -Route nationale -Ouvrage d'art | Plus de 3 | -Hôpital -Clinique | -Ligne électrique, -Transformateur électrique | Plus de 10 000 |

| Degré de vulnérabilité / Classes | Tourisme (nombre établissement par maille) | Activité industrielle et artisanale | Activité tertiaire | Activité primaire |
|----------------------------------|--|---|---------------------------------------|-------------------|
| Nul : 0 | Aucun | Aucun enjeu | Aucun enjeu | Aucun enjeu |
| Faible : 0,25 | 1 | / | / | -Pisciculture |
| Moyen : 0,5 | 2 | -Centrale et barrage hydro-électrique - Chantier naval | -Zone commerciale -Zone d'activité | / |
| Important : 1 | 3 et plus | Zone industrielle et artisanale | Aéroport | -Serre |

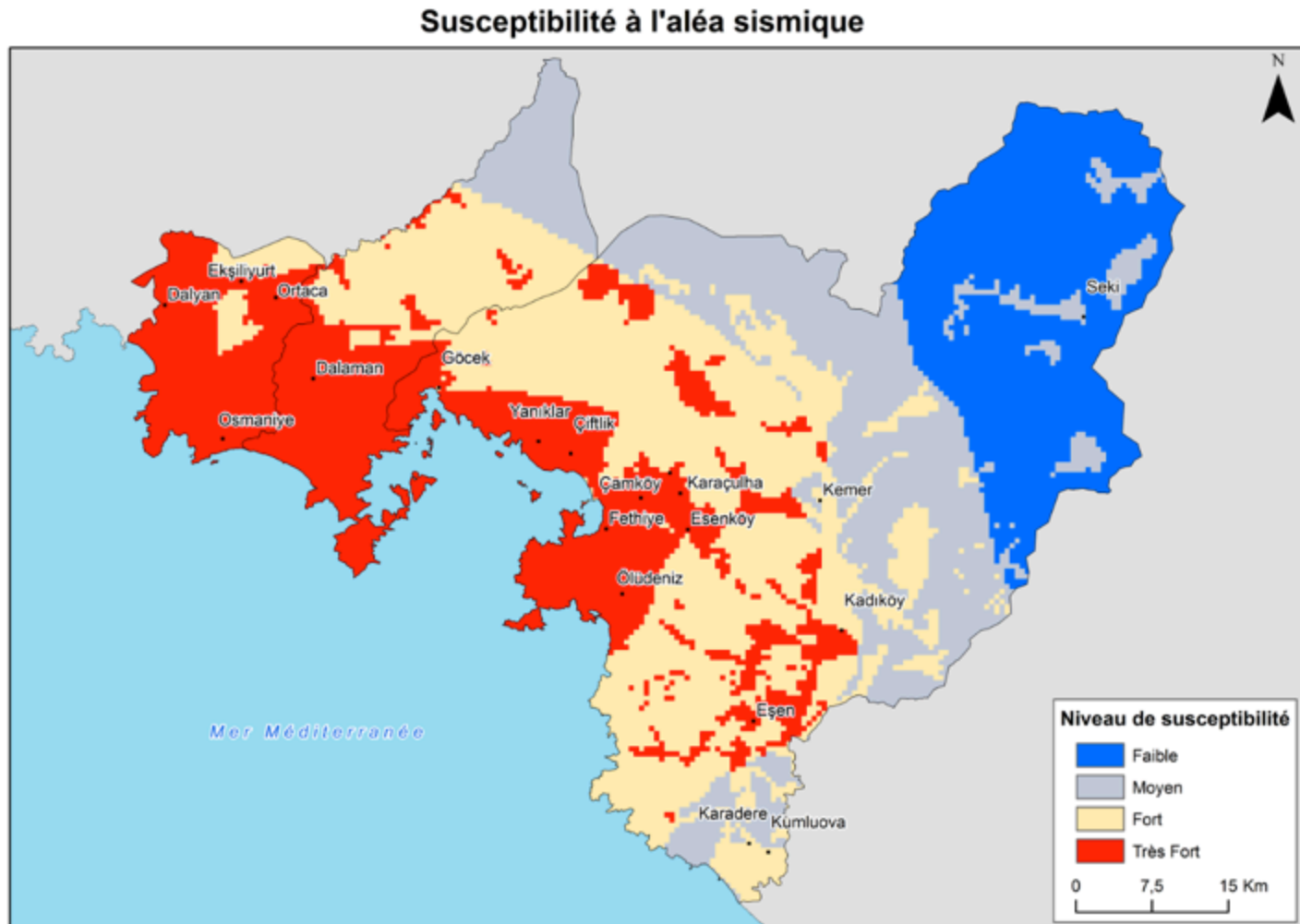
MCA - scoring

| Dimension | Composante | Coefficient |
|----------------------|--|-------------|
| Humain | | 100 |
| | Densité de population | 40 |
| | ERP vulnérable | 35 |
| | Autres espaces concentrant la population | 25 |
| Fonctionnelle | | 100 |
| | Service de santé | 25 |
| | Administration et gouvernement | 25 |
| | Réseau de transport | 20 |
| | Logistique territoriale | 15 |
| | Fonctions sociales | 15 |
| Economique | | 100 |
| | Tourisme | 35 |
| | Activité industrielle et artisanale | 25 |
| | Activité tertiaire | 25 |
| | Activité primaire | 15 |

| | Dimension | Coefficient |
|-----------------------------------|---------------|-------------|
| Vulnérabilité territoriale | | 1 |
| | Humain | 0,5 |
| | Fonctionnelle | 0,3 |
| | Economique | 0,2 |

Historic seismicity assessment

Cumulated intensity (MSK scale) recorded in history, rectified with site effects



Territorial vulnerability map (Fethiye city)

