



Innovative technologies for safer
European coasts in a changing climate

THESEUS DECISION SUPPORT SYSTEM FOR COASTAL RISK ASSESSMENT AND MANAGEMENT

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University of Bologna, Italy

- Title: Innovative coastal technologies for safer European coasts in a changing climate (THESEUS)
- Instrument: Large Integrated Project - FP7
- Total Cost: 8.519.726 €, EC Contribution: 6.530.000 €
- Duration: 48 months, Start Date: 01/12/2009
- Consortium: 31 partners from 18 countries
- Project Coordinator: Barbara Zanuttigh, Università di Bologna (Italy)
- Project Web Site: http://www.theseusproject.eu
- Key Words: coast, flood, erosion, risk, technology, mitigation, adaptation, climate change
- Aim: deliver a safe (or low-risk) coast for human use/development and healthy coastal habitats as sea levels rise and climate changes and the European economy continues to grow.

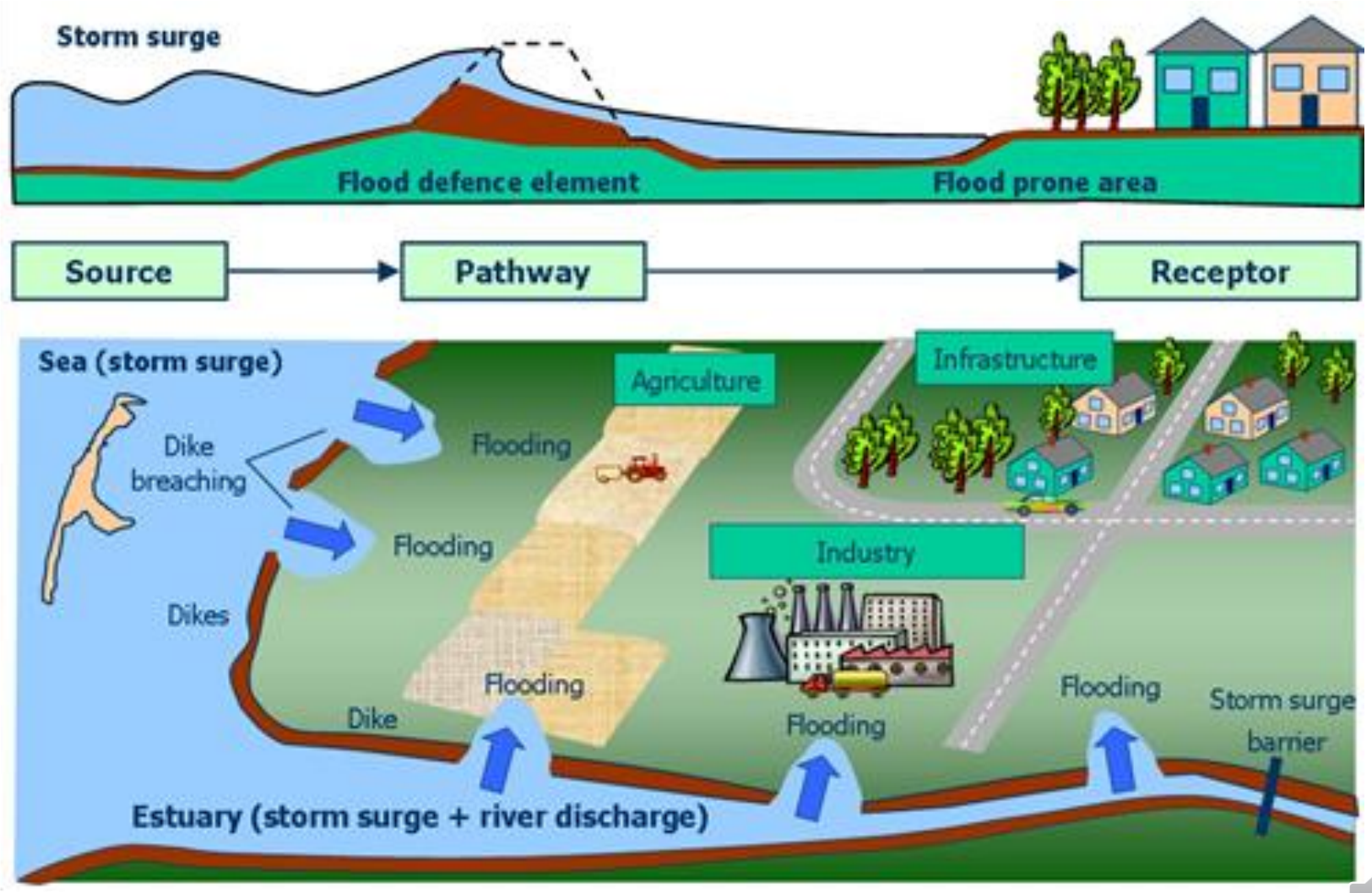
THESEUS Aim

- deliver a safe (or low-risk) coast for human use/development and healthy coastal habitats as sea levels rise and climate changes and the European economy continues to grow.

THESEUS in pratice

- Risk assessment, policy management and planning strategies
  - in cooperation with stakeholders and authorities through applications in 8 sites
  - short, medium, long term scenarios: 2020s, 2050s, 2080s

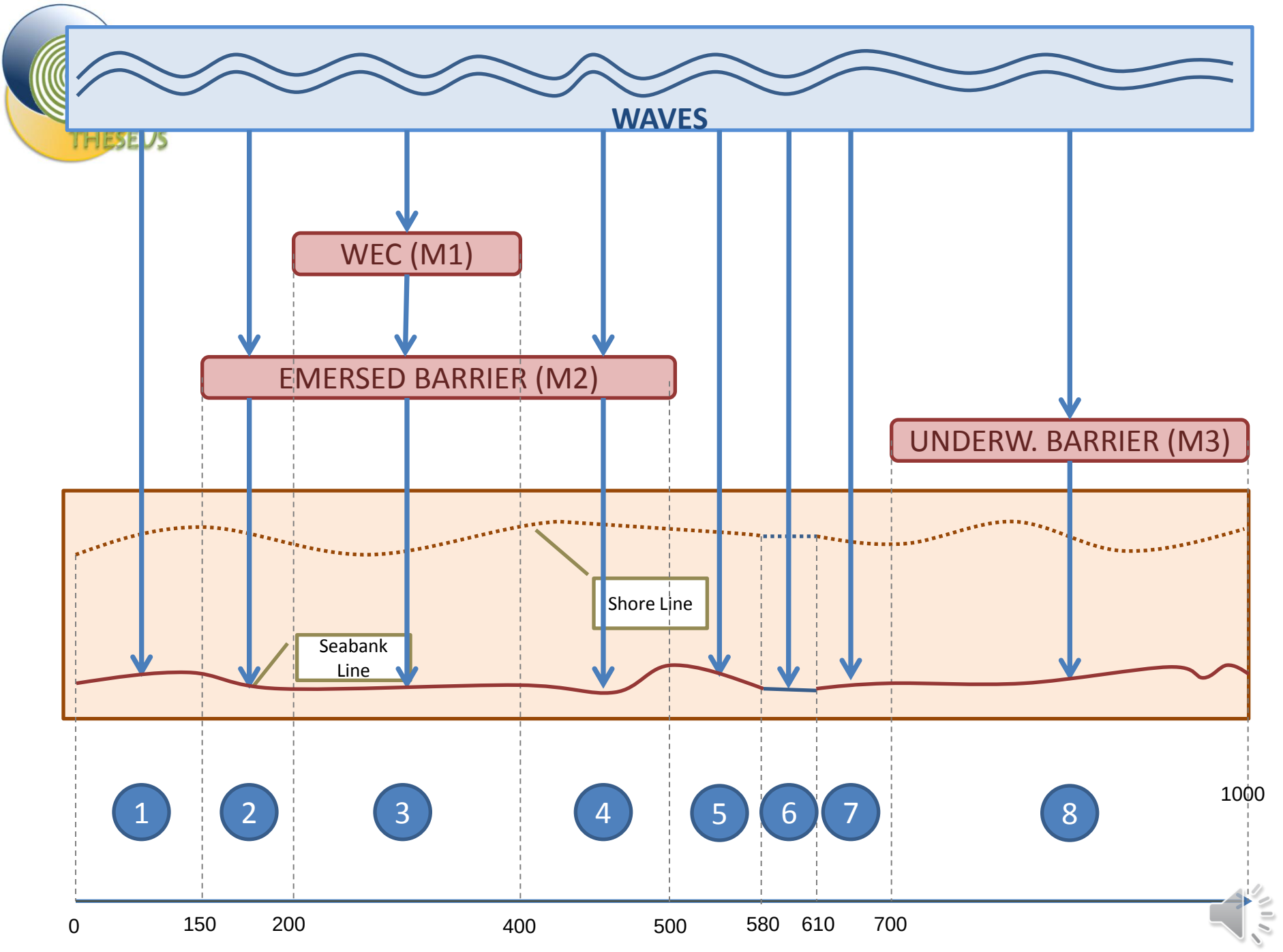
The conceptual framework: SPRC model

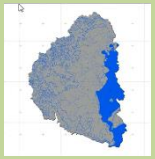


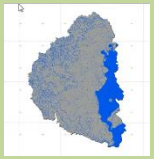
Picture from XtremRisk project

The Decision Support System - overview

- Useful for managers and practitioners
- Coherent with EU policies and vision
- Integrate and make useful most of Theseus findings.
- Spatial scales: 1 to 100 km (order of magnitude)
- Time scales: 1 to 100 years
- Probabilistic approach and multi-scenario analysis
- Simplified representation of all processes
- Modular, scalable and based on durable development platforms
- Applicable to “all” spots. Avoid site-specificity.
- Mixture of innovation + replication/assimilation
- Integrative: of disciplines and data available
- Open and flexible (vs. constrained)


WAVES
WEC (M1)
EMERSED BARRIER (M2)
UNDERW. BARRIER (M3)
Shore Line
Seabank Line
1
2
3
4
5
6
7
8
0
150
200
400
500
580
610
700
1000

1. **WAVES**
2. MITIGATIONS
3. WAVE TRANSFER FUNCTION
4. **WATER SOURCES**
5. WATERSHED FUNCTION
6. FLOODING DEM 
7. ECONOMIC MITIGATIONS | SOCIAL MITIGATIONS | (ECOLOGICAL MITIGATIONS)
   ECONOMIC SCENARIOS | SOCIAL SCENARIOS
   ECONOMIC ANALYSIS | SOCIAL ANALYSIS | ECOLOGICAL ANALYSIS

1. FLOODING DEM 

2. ECONOMIC DATA | SOCIAL DATA | ECOLOGICAL DATA

3. ECONOMIC SCENARIOS | SOCIAL SCENARIOS

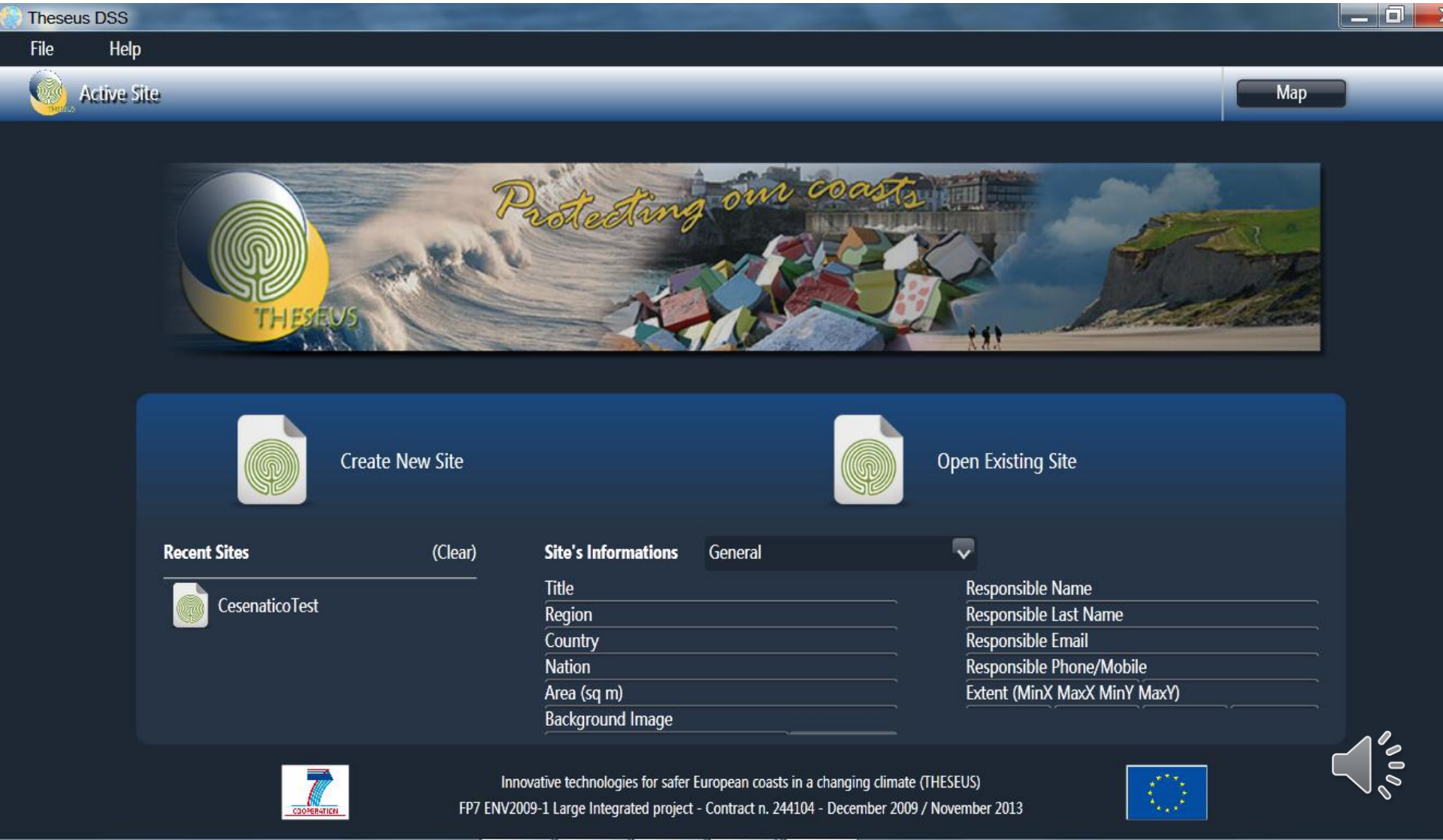
4. ECONOMIC MITIGATIONS | SOCIAL MITIGATIONS | (ECOLOGICAL MITIGATIONS)

5. ECONOMIC DAMAGE FUNCTION | SOCIAL DAMAGE FUNCTION | ECOLOGICAL DAMAGE FUNCTION

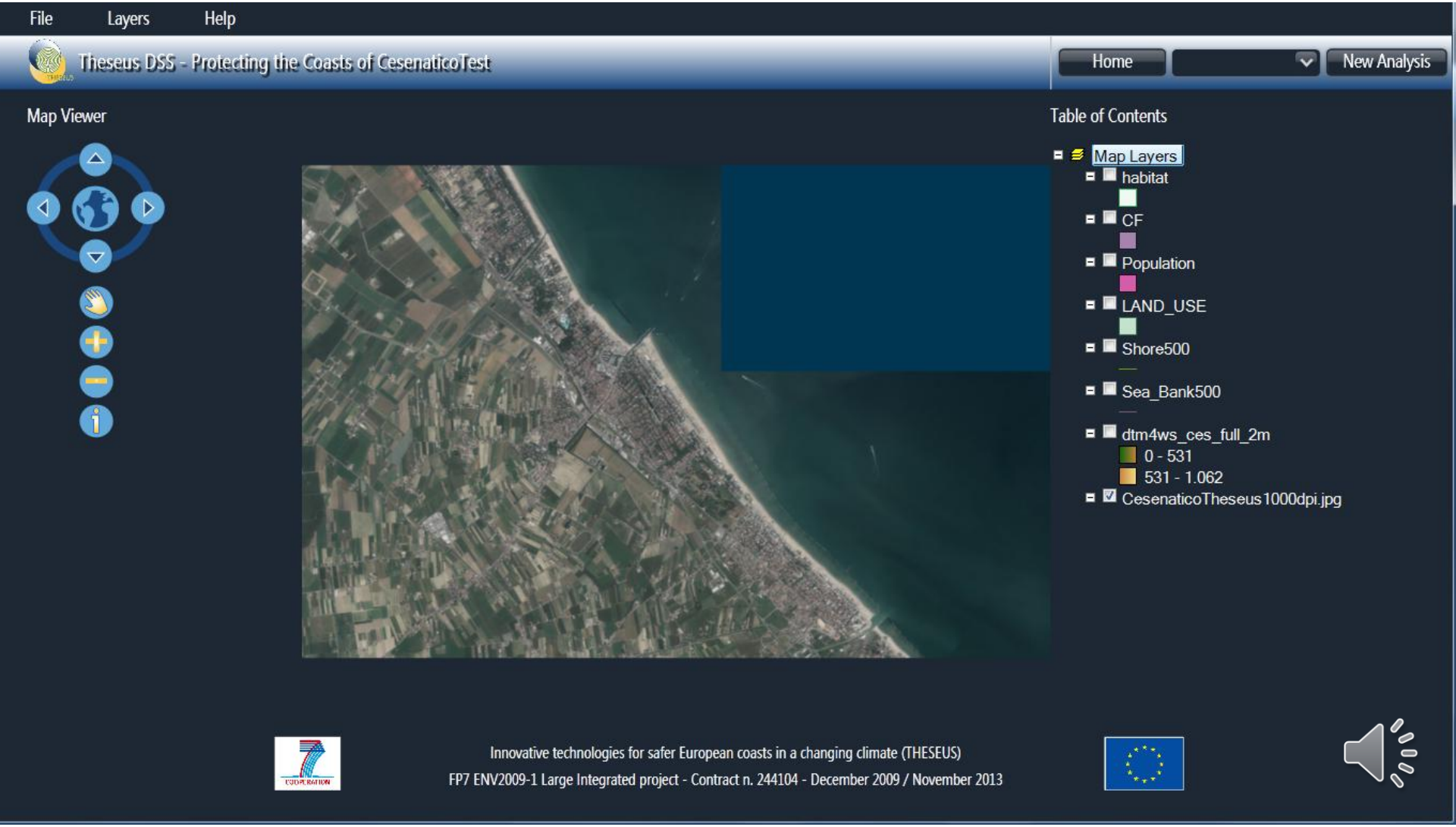
6. **ECONOMIC DAMAGE** | **SOCIAL DAMAGE** | **ECOLOGICAL DAMAGE**

7. **TOTAL RISK ASSESSMENT**

The Decision Support System



Map GUI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Sea_Bank500
dtm4ws_ces_full_2m
0 - 531
531 - 1.062
CesenaticoTheseus1000dpi.jpg
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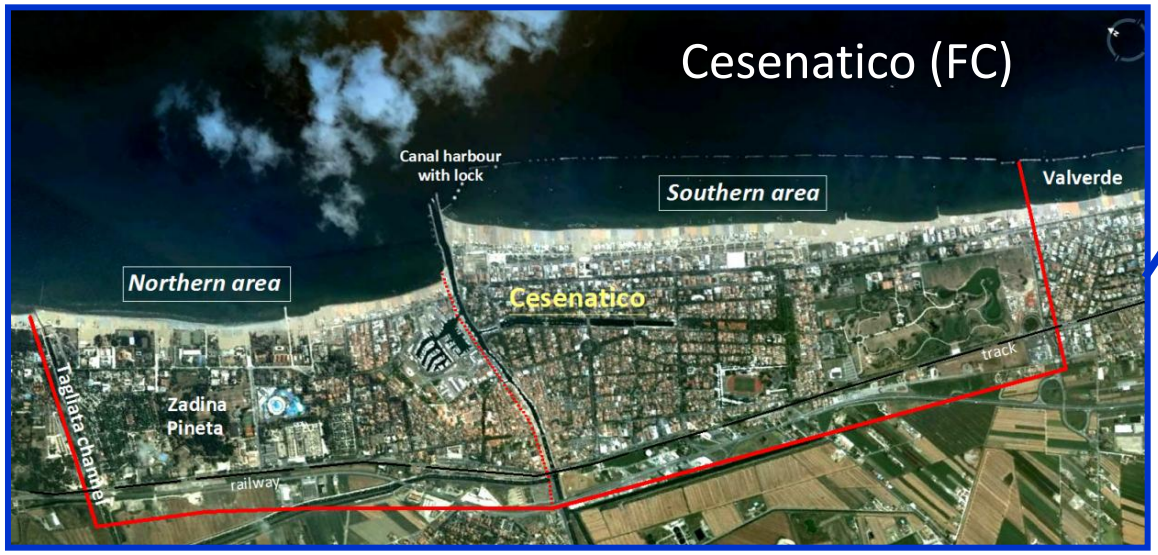
The Po Delta site



Cesenatico: flooding in the urban area

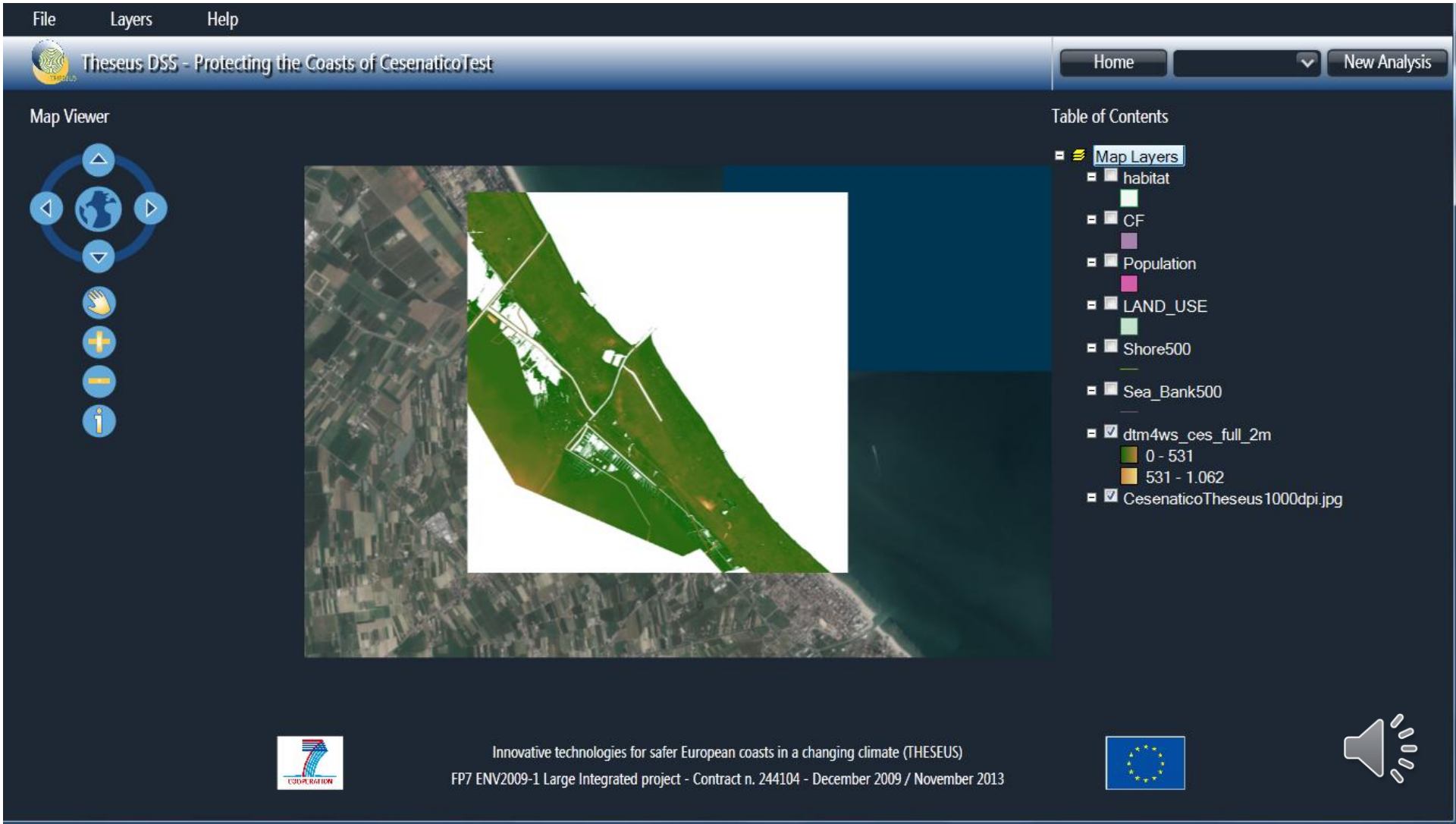
Cesenatico (FC)

Boundaries

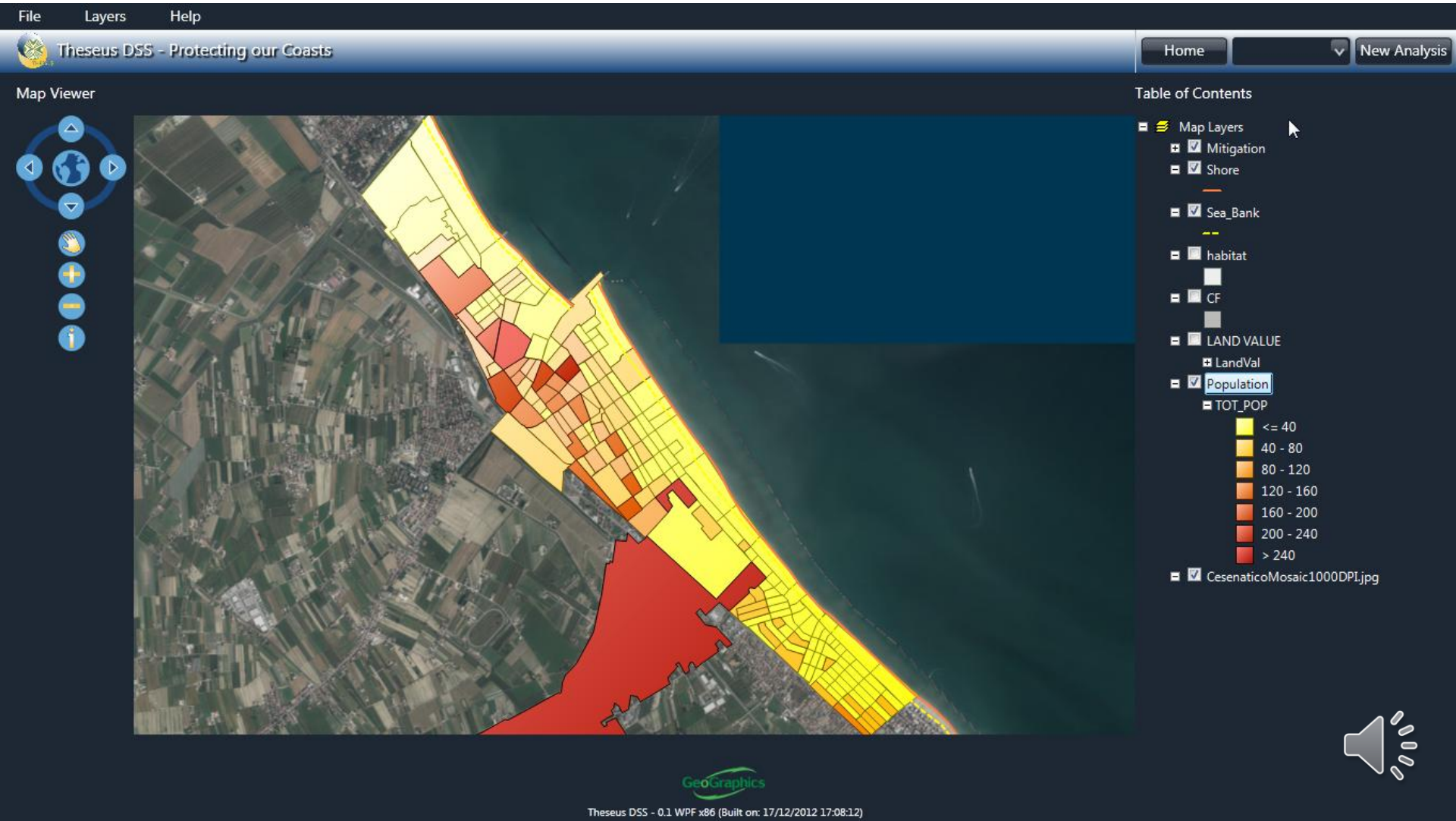
- Northern, Tagliata Channel
- Southern, Valverde
- Western, railway track

Existing management

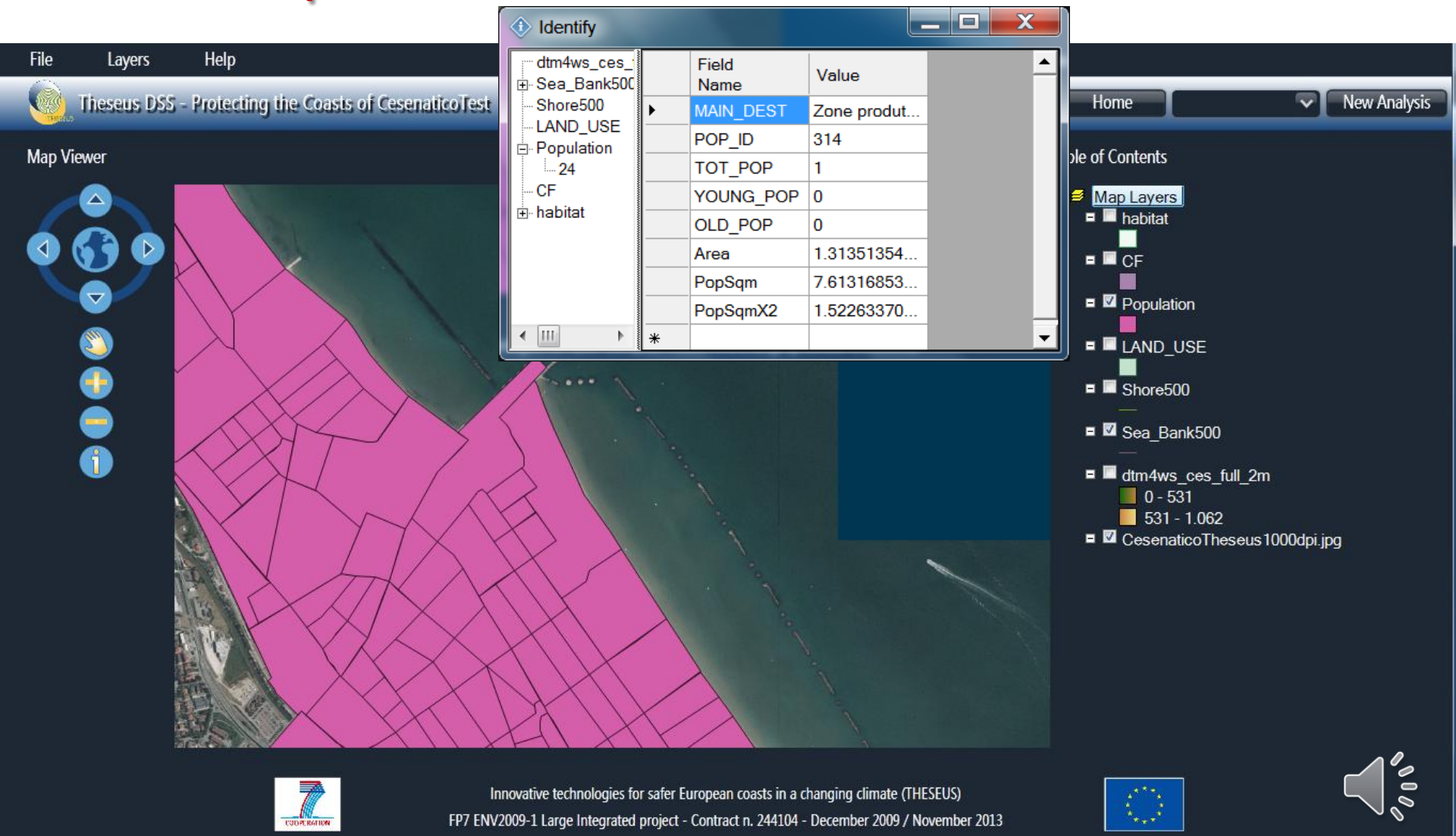
THESEUS DSS @Cesenatico



Population density



Population


Identify
dtm4ws_ces_
Sea_Bank500
Shore500
LAND_USE
Population
24
CF
habitat
Field Name
Value
MAIN_DEST
Zone produt...
POP_ID
314
TOT_POP
1
YOUNG_POP
0
OLD_POP
0
Area
1.31351354...
PopSqm
7.61316853...
PopSqmX2
1.52263370...
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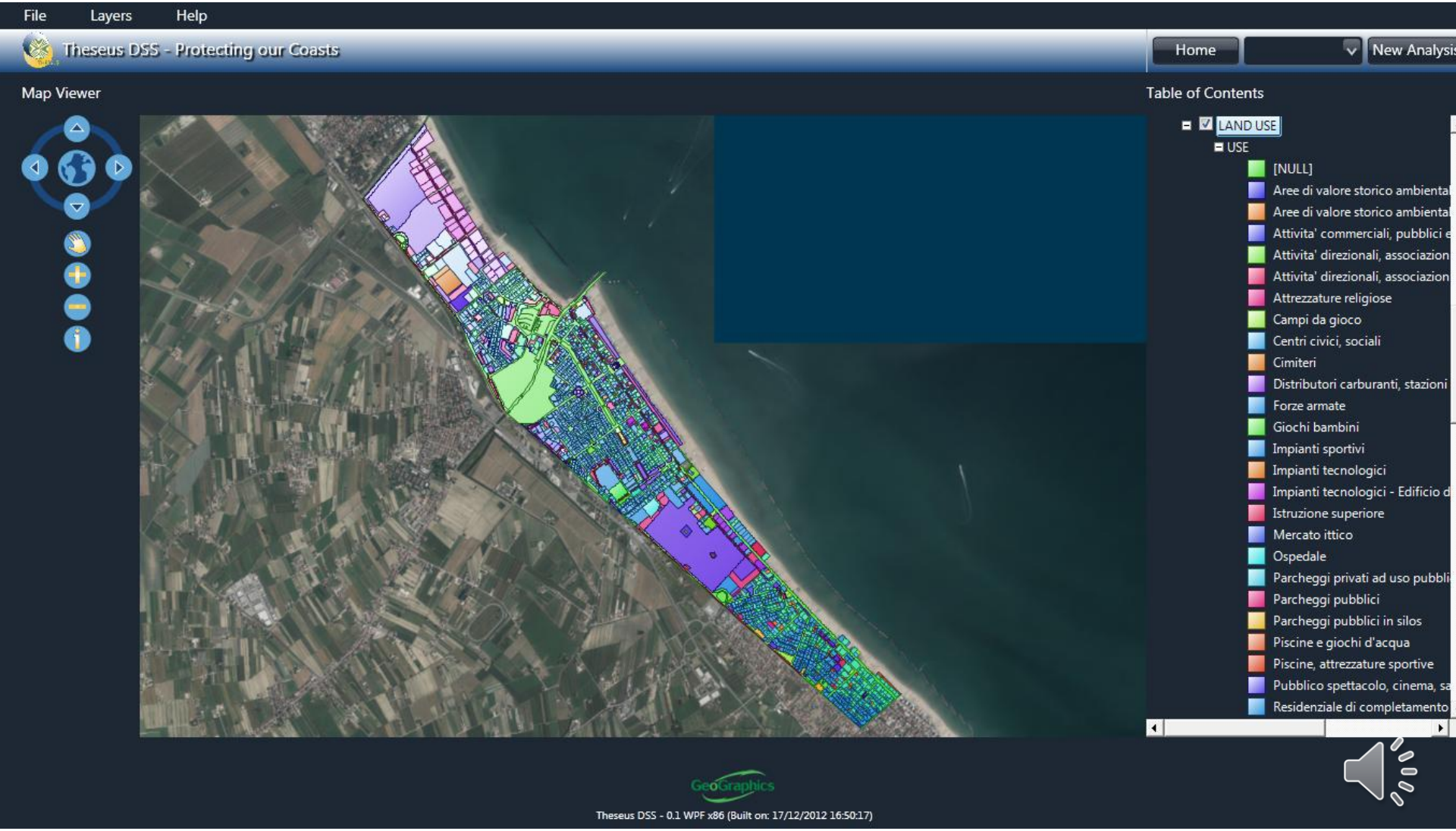
Land use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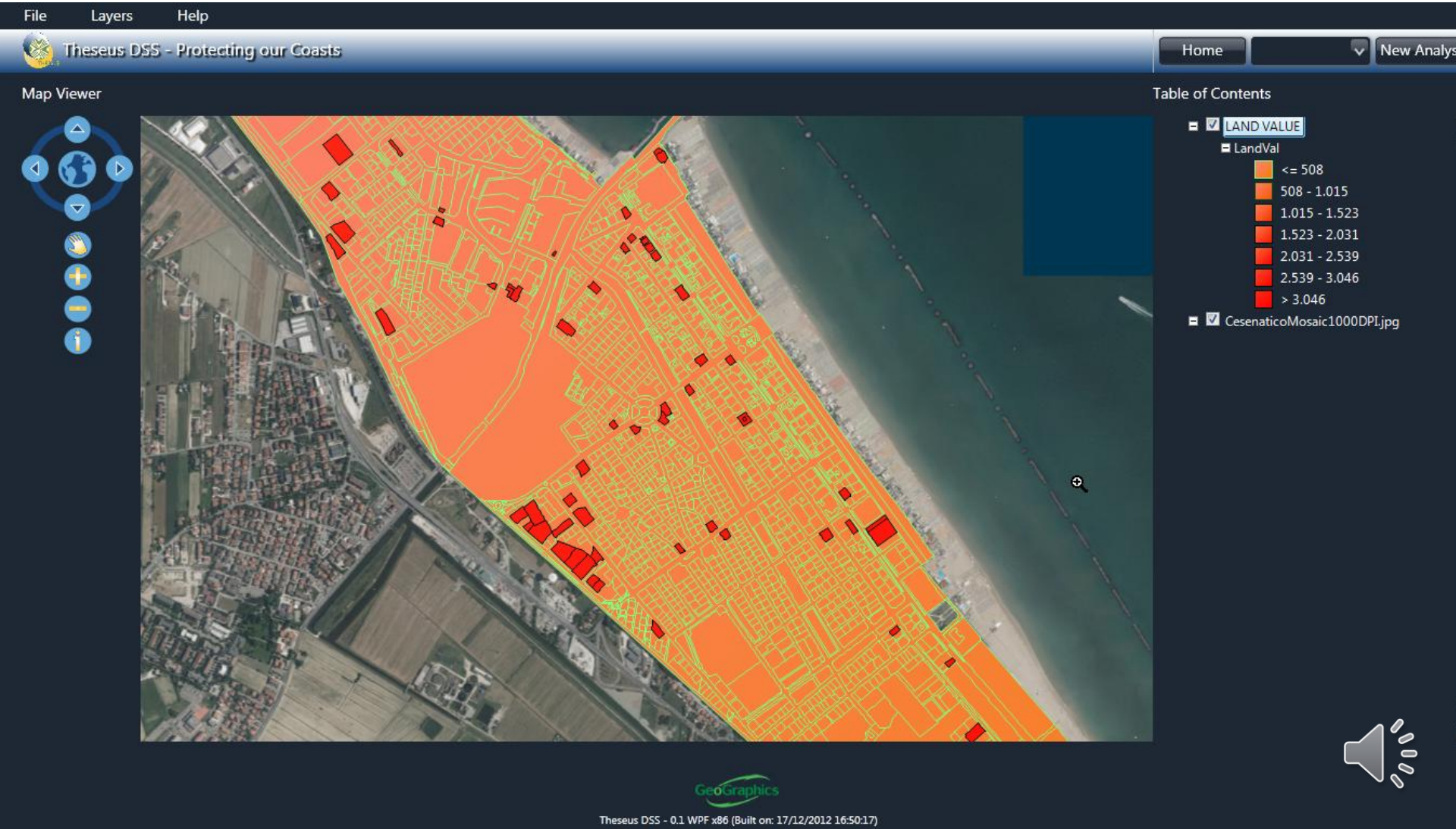
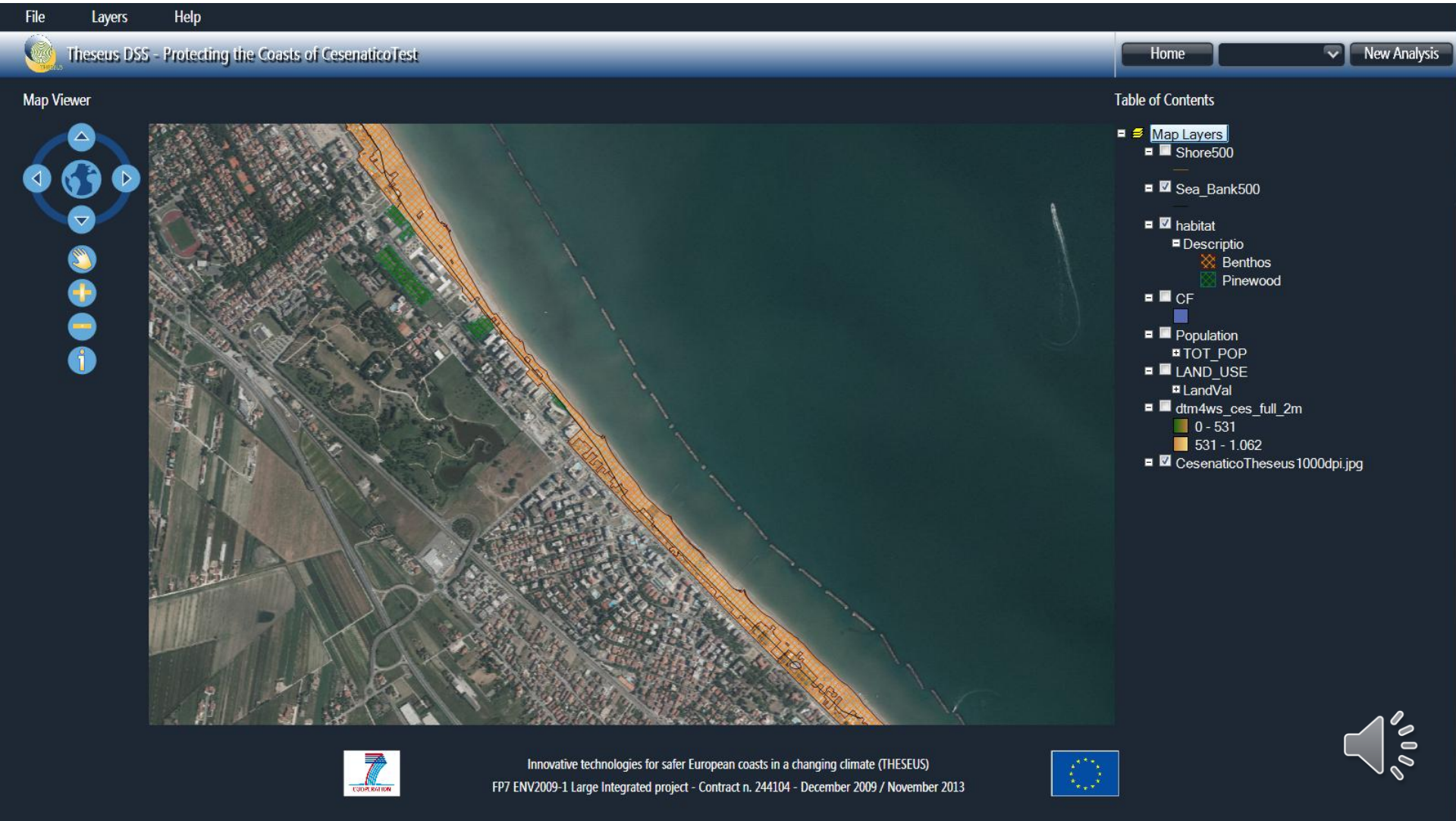
USE
[NULL]
Aree di valore storico ambientale
Aree di valore storico ambientale
Attivita' commerciali, pubblici e
Attivita' direzionali, associazion
Attivita' direzionali, associazion
Attrezzature religiose
Campi da gioco
Centri civici, sociali
Cimiteri
Distributori carburanti, stazioni
Forze armate
Giochi bambini
Impianti sportivi
Impianti tecnologici
Impianti tecnologici - Edificio d
Istruzione superiore
Mercato ittico
Ospedale
Parcheggi privati ad uso pubbli
Parcheggi pubblici
Parcheggi pubblici in silos
Piscine e giochi d'acqua
Piscine, attrezzature sportive
Pubblico spettacolo, cinema, sa
Residenziale di completamento
GeoGraphics
Theseus DSS - 0.1 WPF x86 (Built on: 17/12/2012 16:50:17)

Spatial distribution of GDP



Habitats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Theseus DSS - Analysis Editor
Meteomarine Climate Scenario
Preset
Time Slice:
2010 - Present
Return Period:
2 Years
User Defined
Name:
Year:
Include Erosion
Sea Gate open (Failure Scenario)
Hs (m):
1
2
2.000
Sop (%):
0.1
1.5
1.305
Zm (m):
0.5
3.6
1.143
Zr (m):
0
10
0.0
Environmental Scenario
S (cm/year):
0.1
2
1.000
Economic Scenario
Preset
No Growth
User Defined
Name:
GDP Rate:
-0.5
0.1
0.0
Social Scenario
Preset
No Growth
User Defined
Name:
POP Rate:
-0.5
0.1
0.0
Previous
Cancel
Next


Theseus DSS - Analysis Window
Definition
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Theseus DSS - Analysis Editor
Engineering Mitigation
Wave Energy Farm (DEXA)
Wave Energy Farm (Wave Dragon)
Floating Breakwaters
Sea Walls
Barriers
Emerged Nourishment
Submerged Nourishment
Economic Mitigations
Land Use Change
Insurance Premium
Environmental Mitigations
Dunes
Biogenic Reef
Saltmarsh creation/management
Seagrasses
Social Mitigations
Evacuation Plan
Use Calculator
Calculate
Estimated % of evacuated people
0
100
0.0
Previous
Cancel
Next


Definition
Scenario
Mitigations
Execute
Theseus DSS - Analysis Editor
Engineering Mitigation
Wave Energy Farm (DEXA)
Wave Energy Farm (Wave Dragon)
Floating Breakwaters
Sea Walls
Barriers
Emerged Nourishment
Submerged Nourishment
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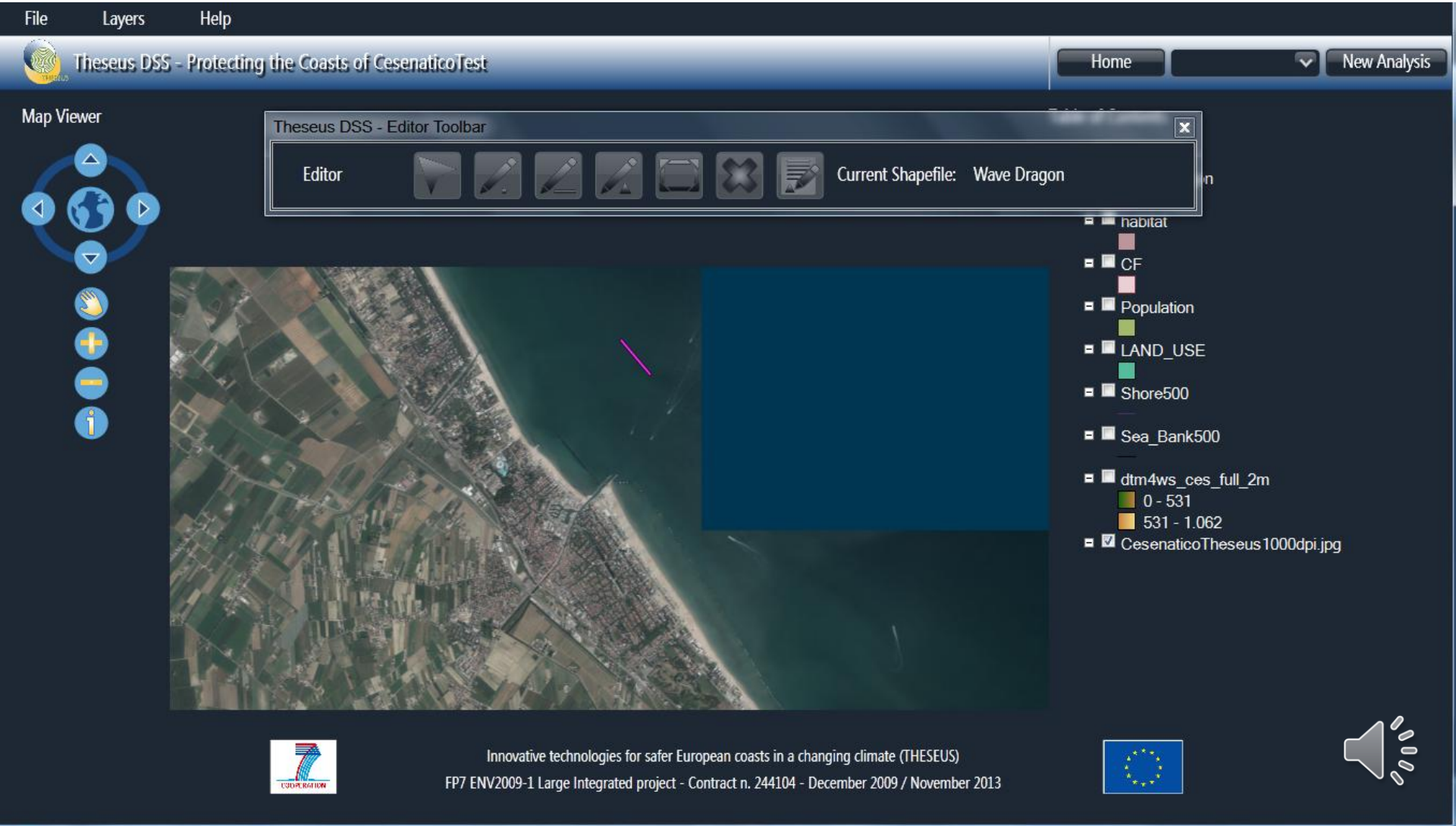
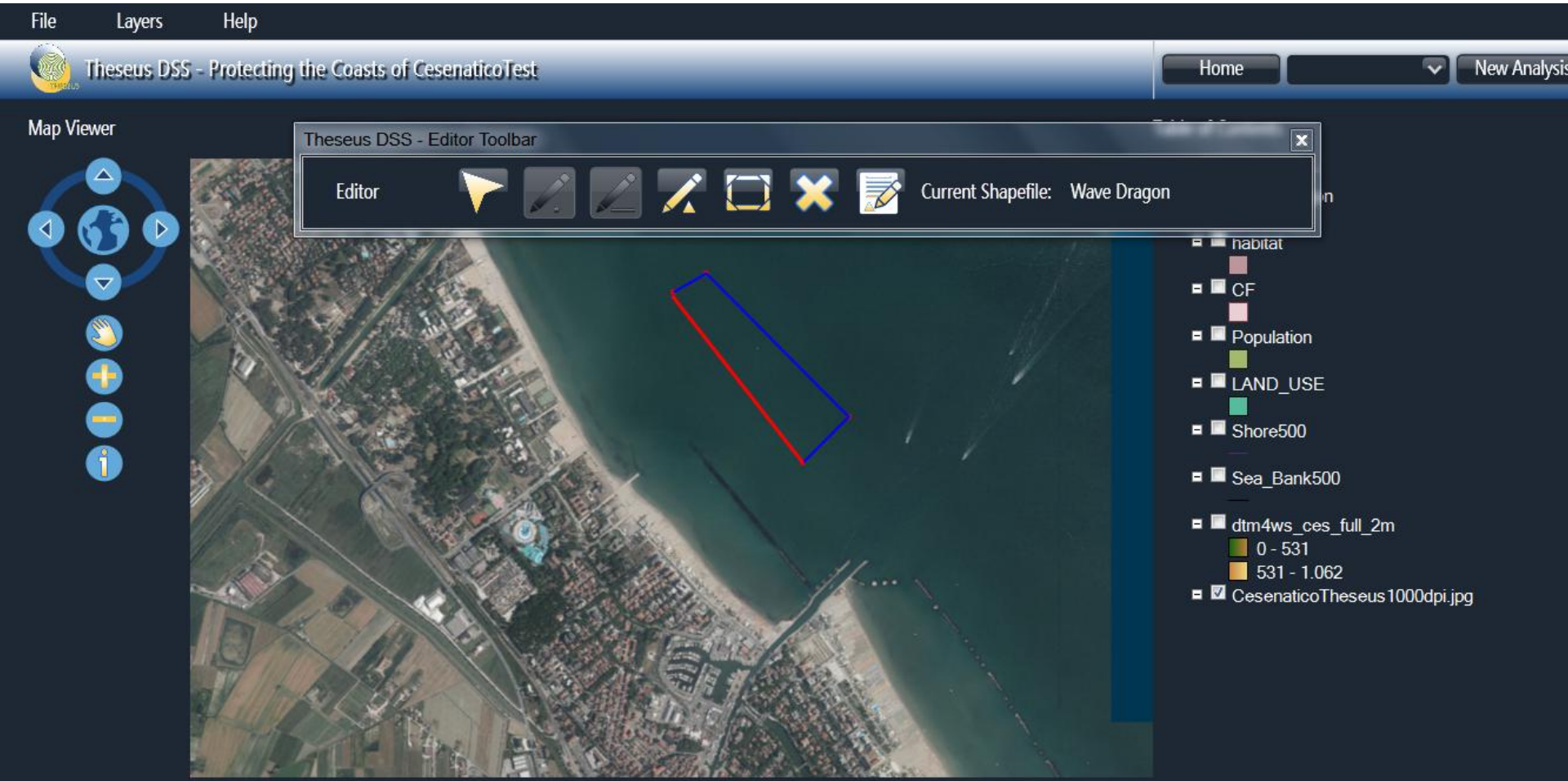
Seagrasses
Social Mitigations
Evacuation Plan
Use Calculator
Calculate
Estimated % of evacuated people
0
100
0.0
Previous
Cancel
Next

Mitigations: editing



Mitigations: editing



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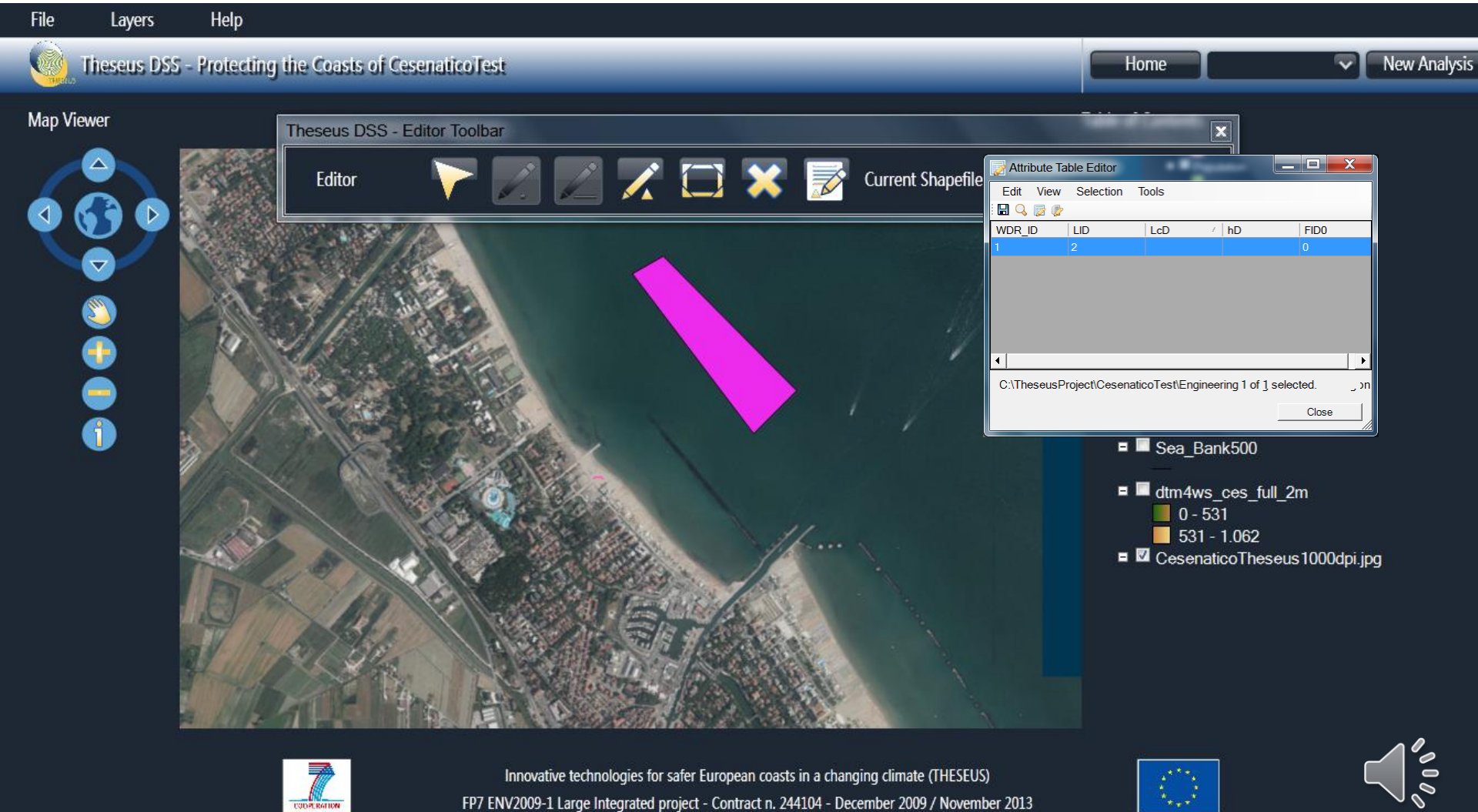
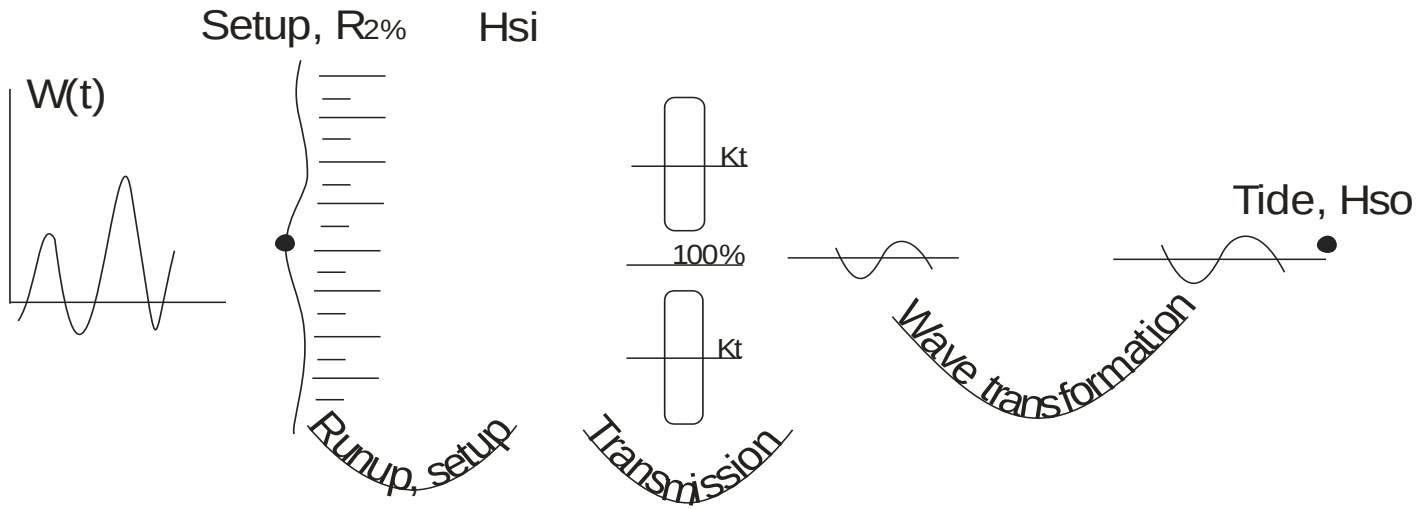
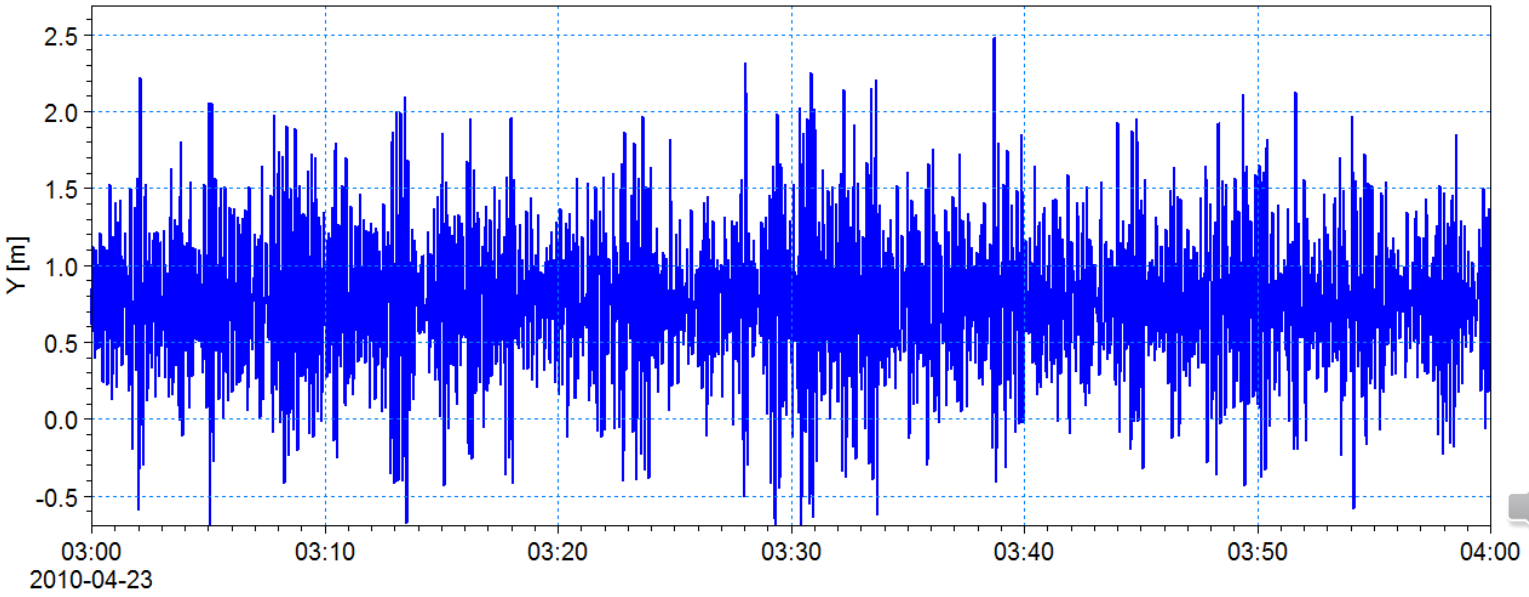
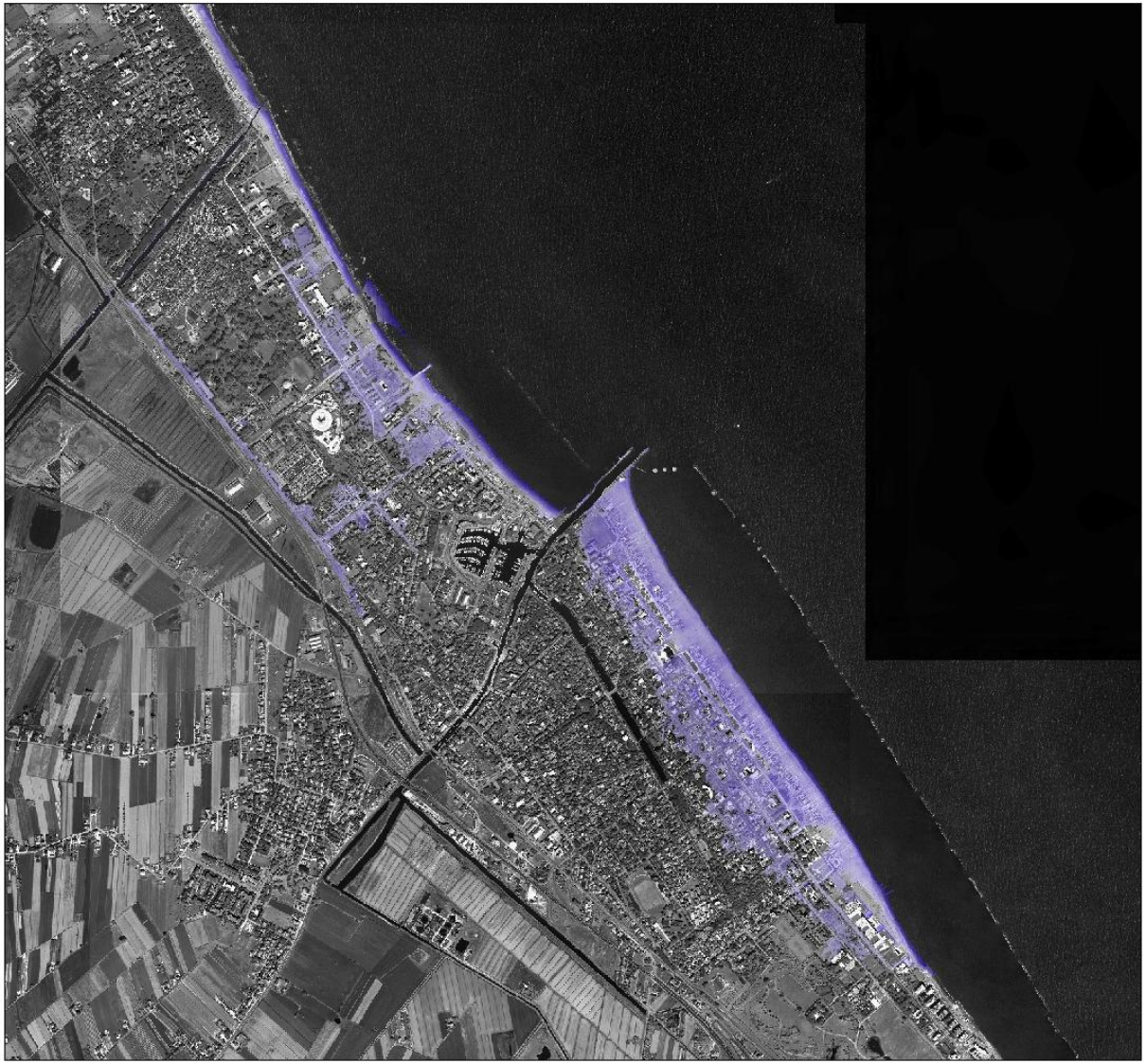


Shoreline boundary condition

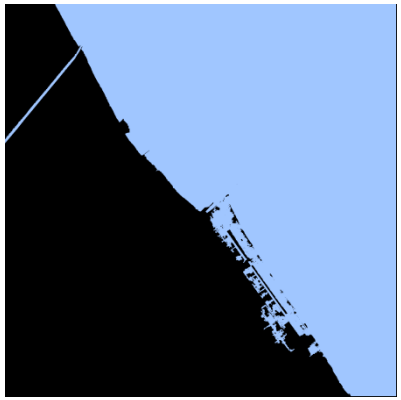




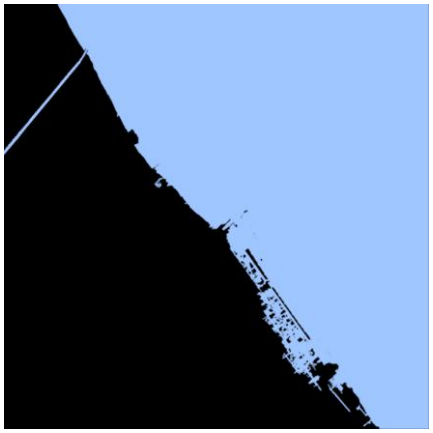
Simplified GIS based model



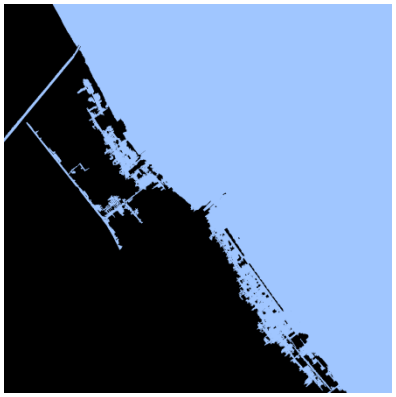
Watershed Segmentation Models: Finite Volume



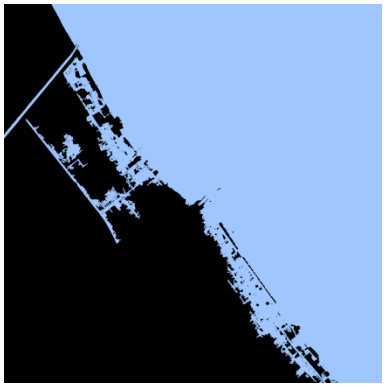
8 Mmc



15 Mmc

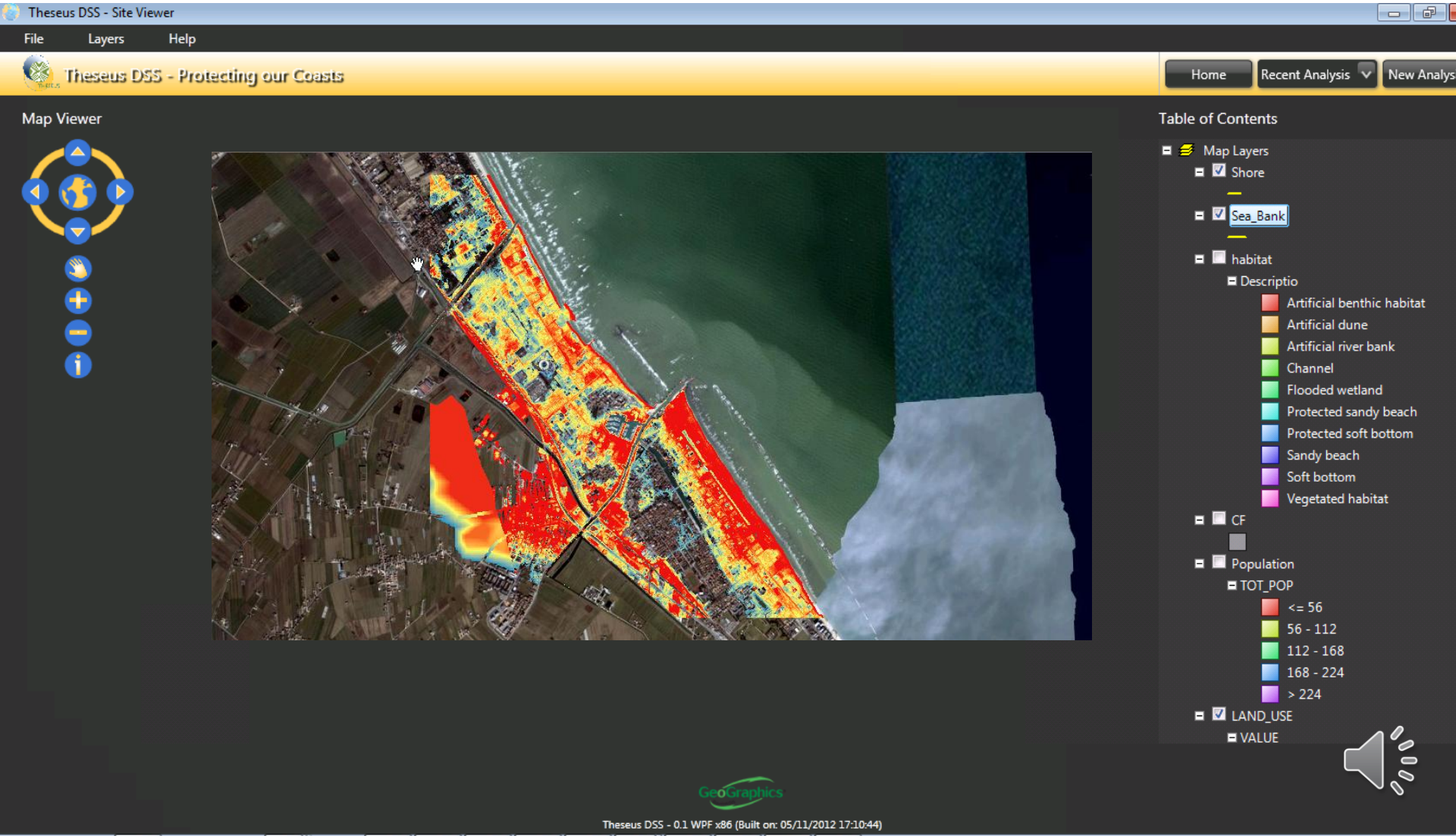


25 Mmc



35 Mmc

Flood Depth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Protected sandy beach
Protected soft bottom
Sandy beach
Soft bottom
Vegetated habitat
CF
Population
TOT_POP
<= 56
56 - 112
112 - 168
168 - 224
> 224
LAND_USE
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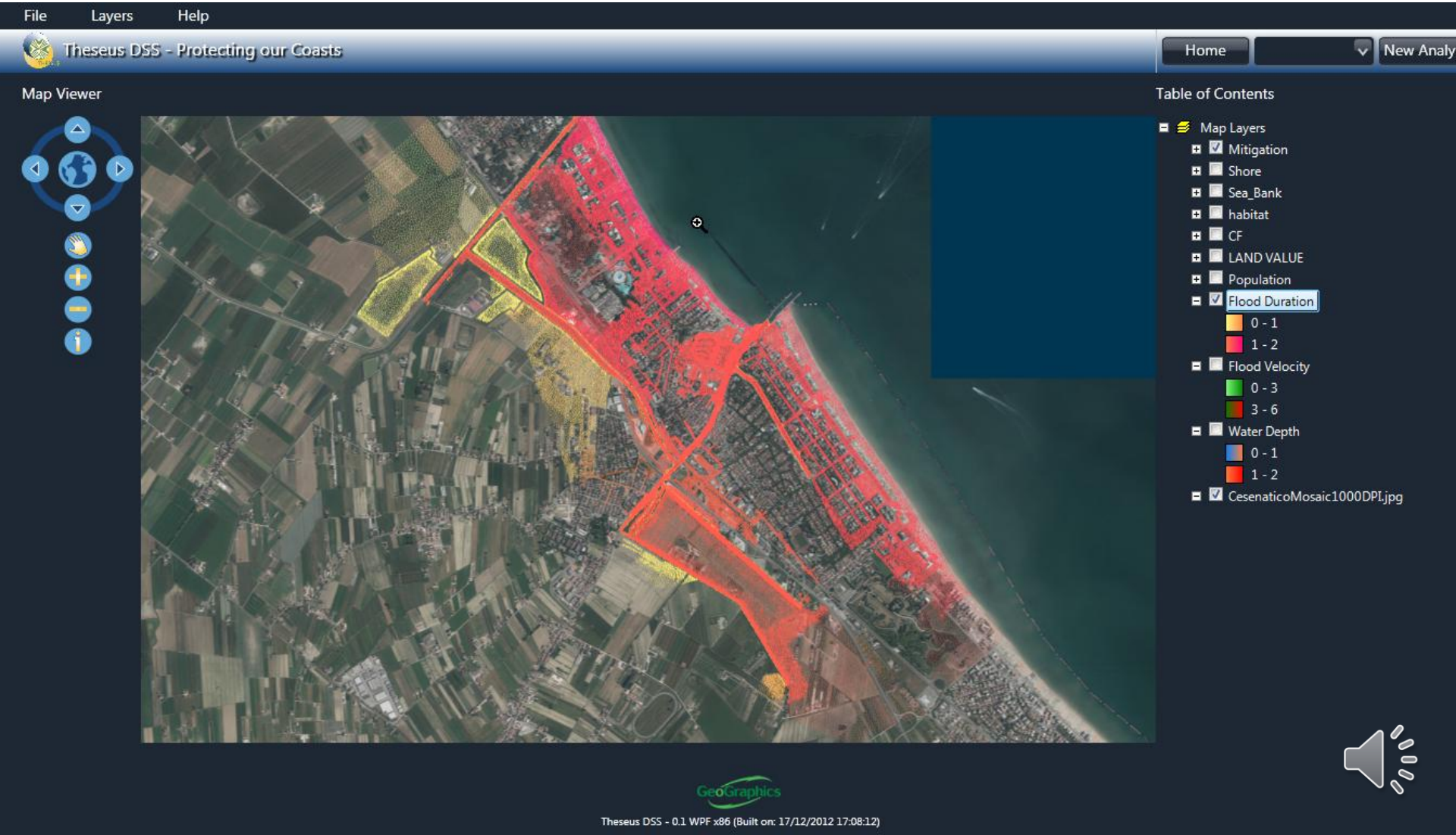
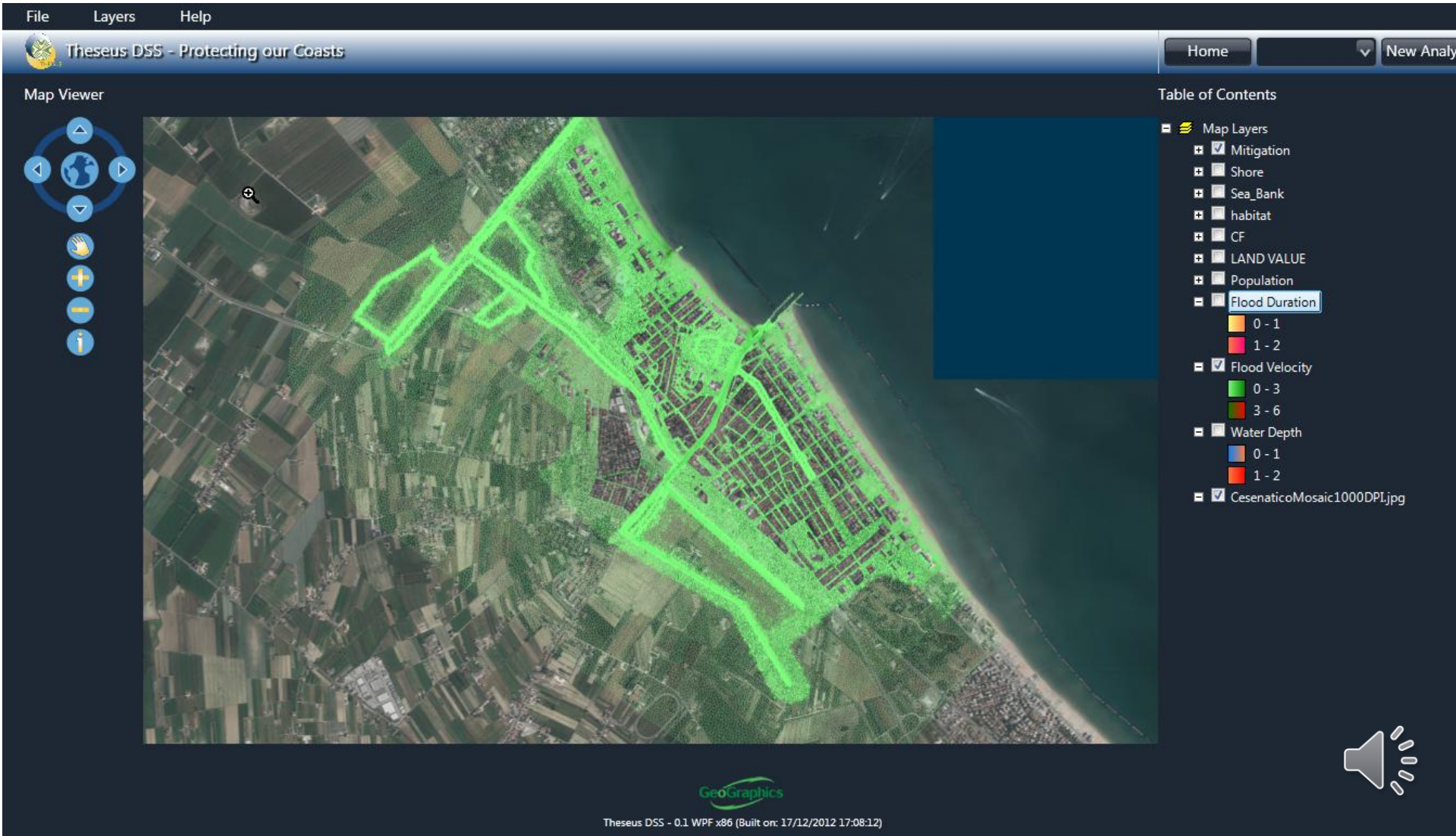
Flood Duration



Flood Velocity



Environmental vulnerability

	Negligible	Transient effect (no long term change anticipated)	Moderate effect/Semi permanent change	Permanent effect/change
EVI Index	0	1	2	3
Habitat / Key species	Negligible impact to habitats / species	Changes within the range of Receptor's natural seasonal variation and full recovery is likely within a season	Changes are beyond Receptor's natural seasonal variation. Partial recovery is possible within several seasons, but full recovery is likely to require human intervention, or greater than 20 years for natural recovery	Changes are so drastic that natural recovery of receptor is very unlikely without human intervention. Or natural recovery will take longer than 20 years

Environment vulnerability assessment

Sampling, Historical data

Temperature
Wind
Currents
Granulometry
Sediment transport
……

FBEM learning algorithm

FBEM predictive algorithm

New sampling, Physical model, On line data

Δ Temperature
Δ wind
Δ currents
Δ granulometry
Δ sediment transport
……

Biological variables

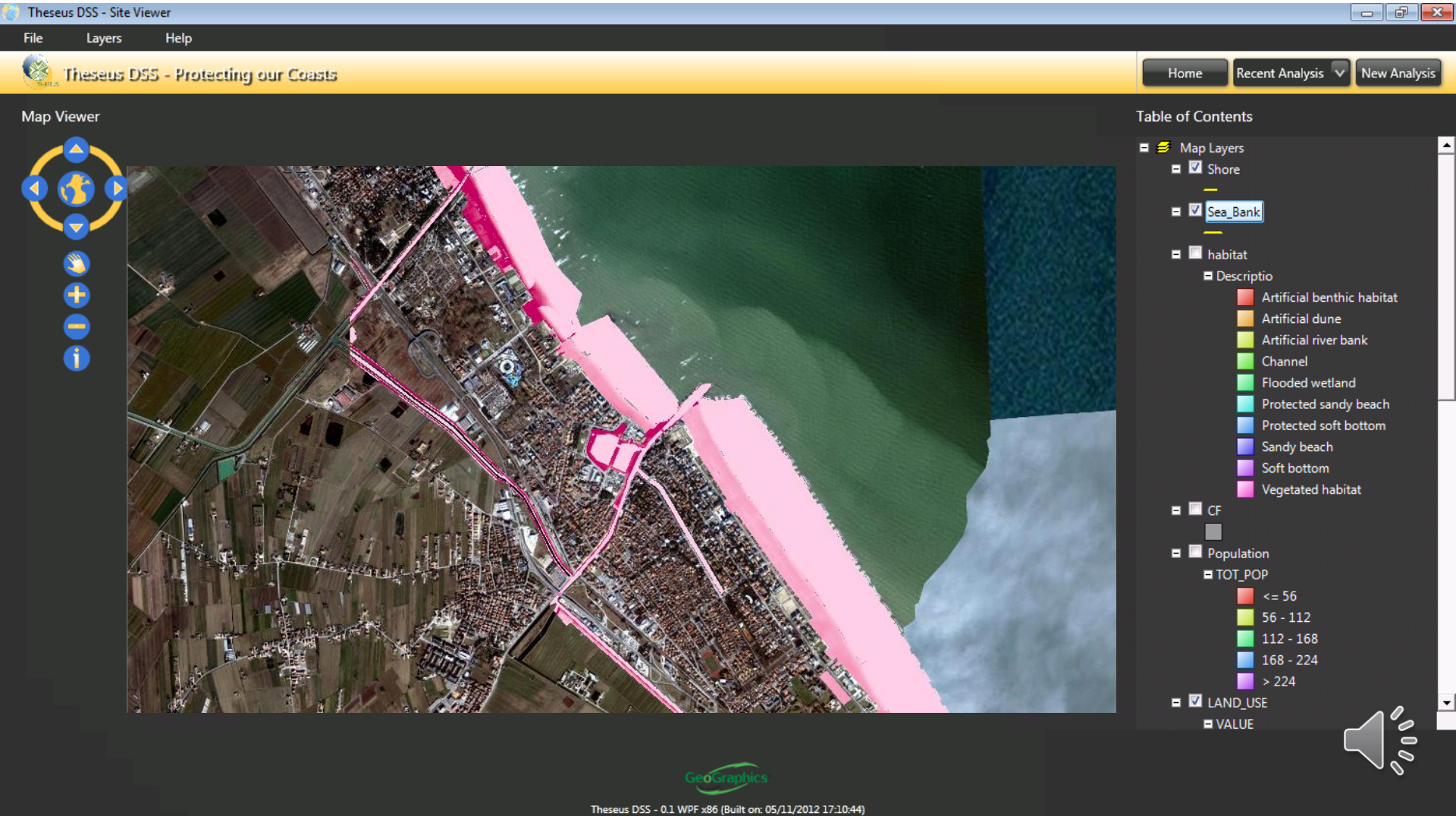
Δ biological variables + biological autocorrelation

WT 1.5

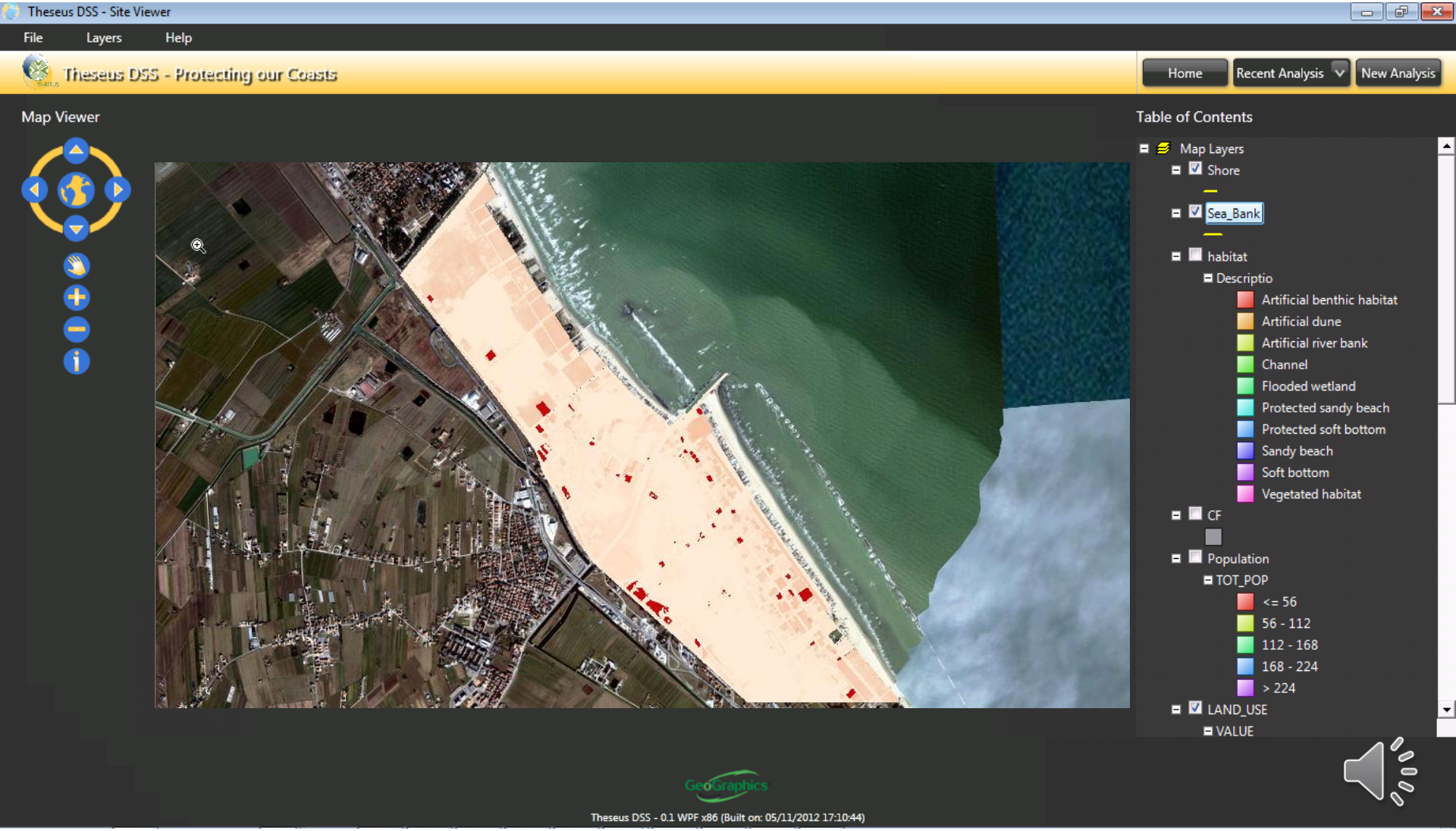
EVI example for grasslands

Days	0.02	0.04	0.08	0.17	0.25	0.50	1	2	3	4	5	6	7	14	28	
Hours	0.5	1	2	4	6	12	24	48	72	96	120	144	168	336	672	Permanent
0.01	0	0	0	0	0	0	1	1	1	2	2	2	2	2	2	3
0.05	0	0	0	0	0	0	1	1	1	2	2	2	2	2	2	3
0.1	0	0	0	0	0	0	1	1	1	2	2	2	2	2	2	3
0.5	0	0	0	0	0	0	1	1	1	2	2	2	2	2	2	3
1	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3
2	1	1	1	1	1	1	2	3	3	3	3	3	3	3	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
48	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
52	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
365	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

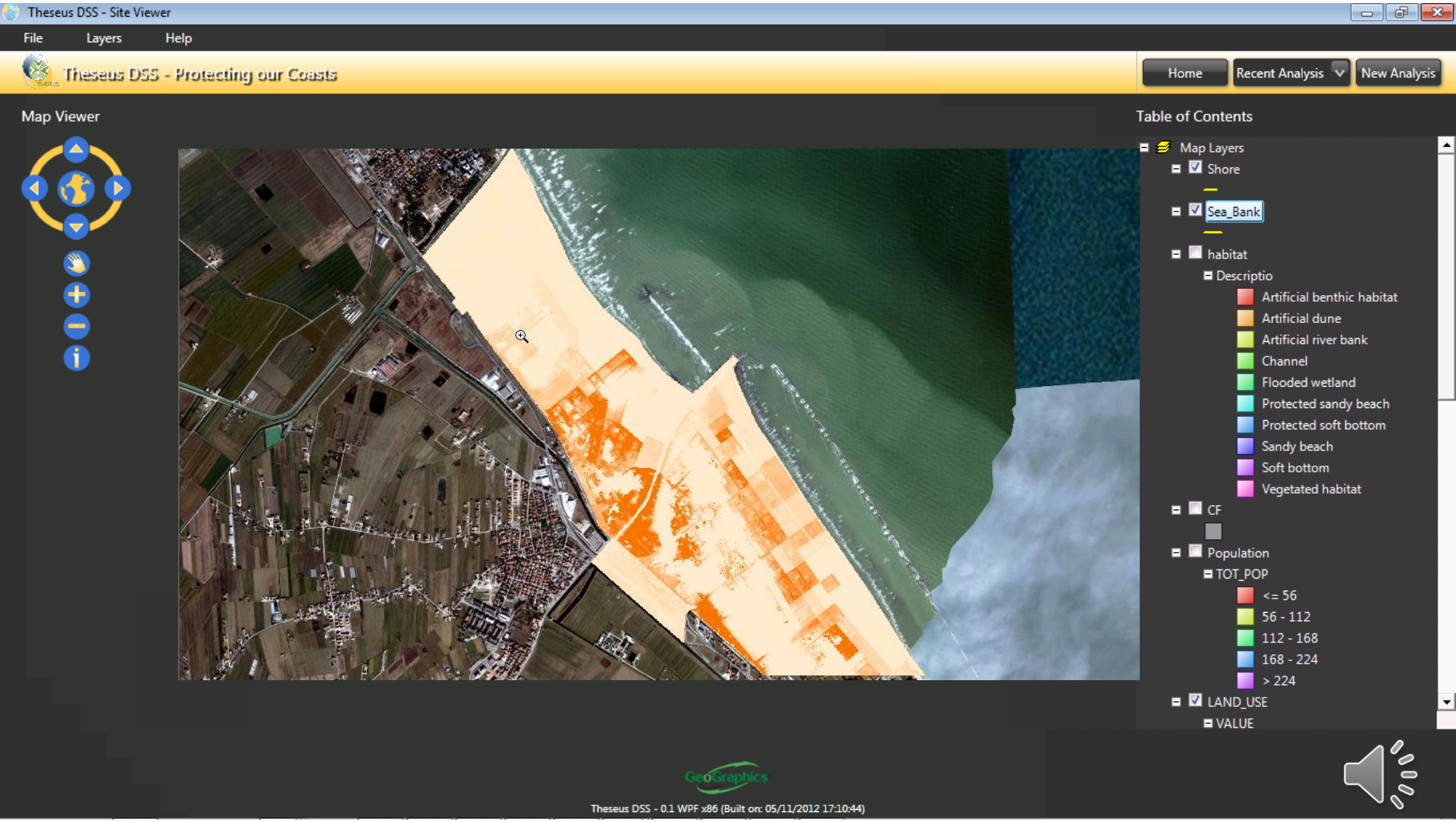
Ecological Vulnerability



Land Value Loss



Life Loss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> 224
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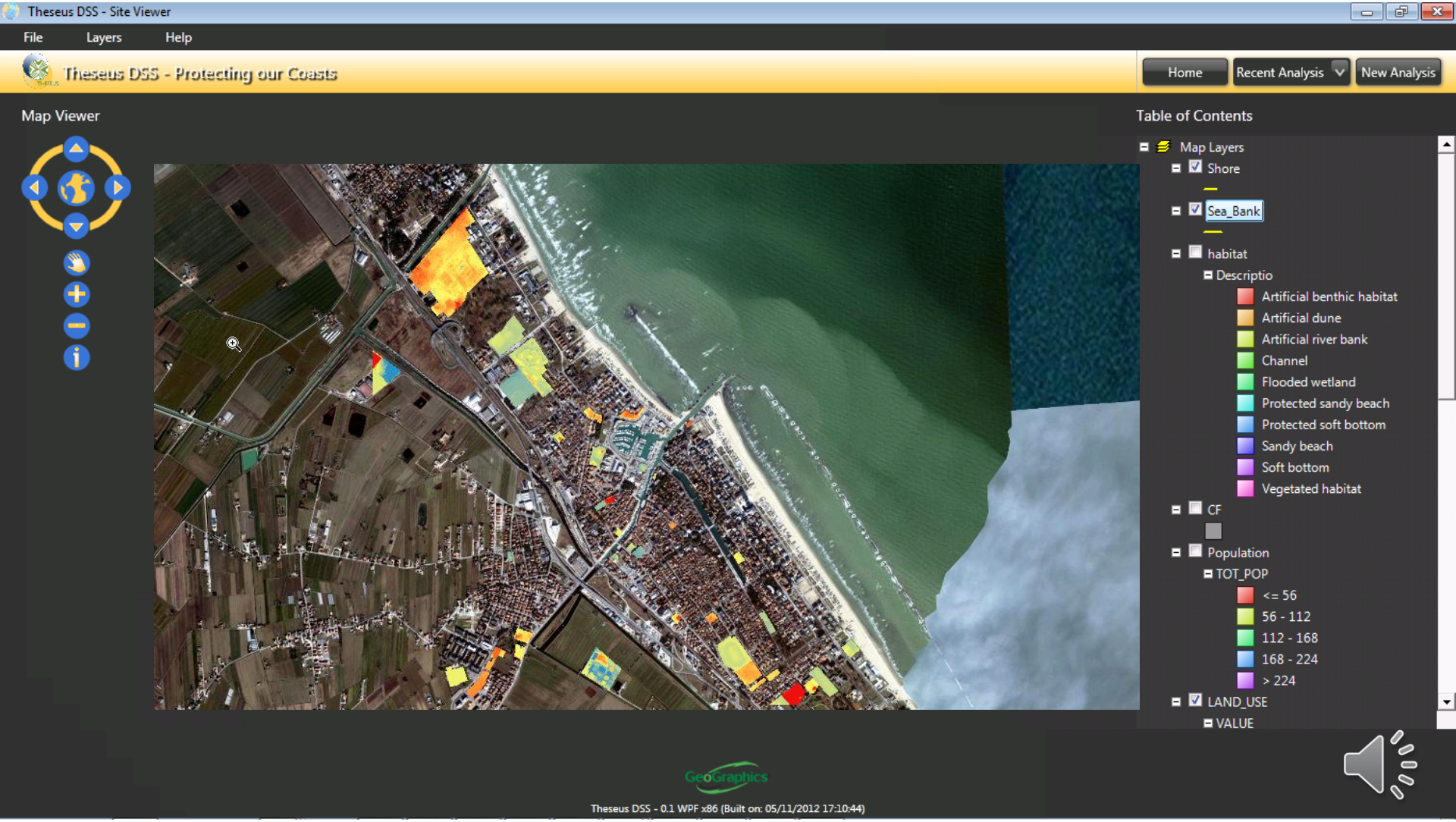
Critical Facilities Loss



Vulnerability maps

- Hydraulic vulnerability map
  - Flood depth (defined site specific thresholds)
  - Flood duration (defined site specific thresholds)
  - Flood velocity (defined site specific thresholds)
- Ecological vulnerability map: EVI
- Social vulnerability map
  - Life losses (VI based on % of total population)
  - Critical facilities losses (VI based on literature)
- Economic vulnerability map
  - Loss of goods and properties, business disruption VI based on % of total damage)
  - Beach loss (VI base on % of total beach loss)

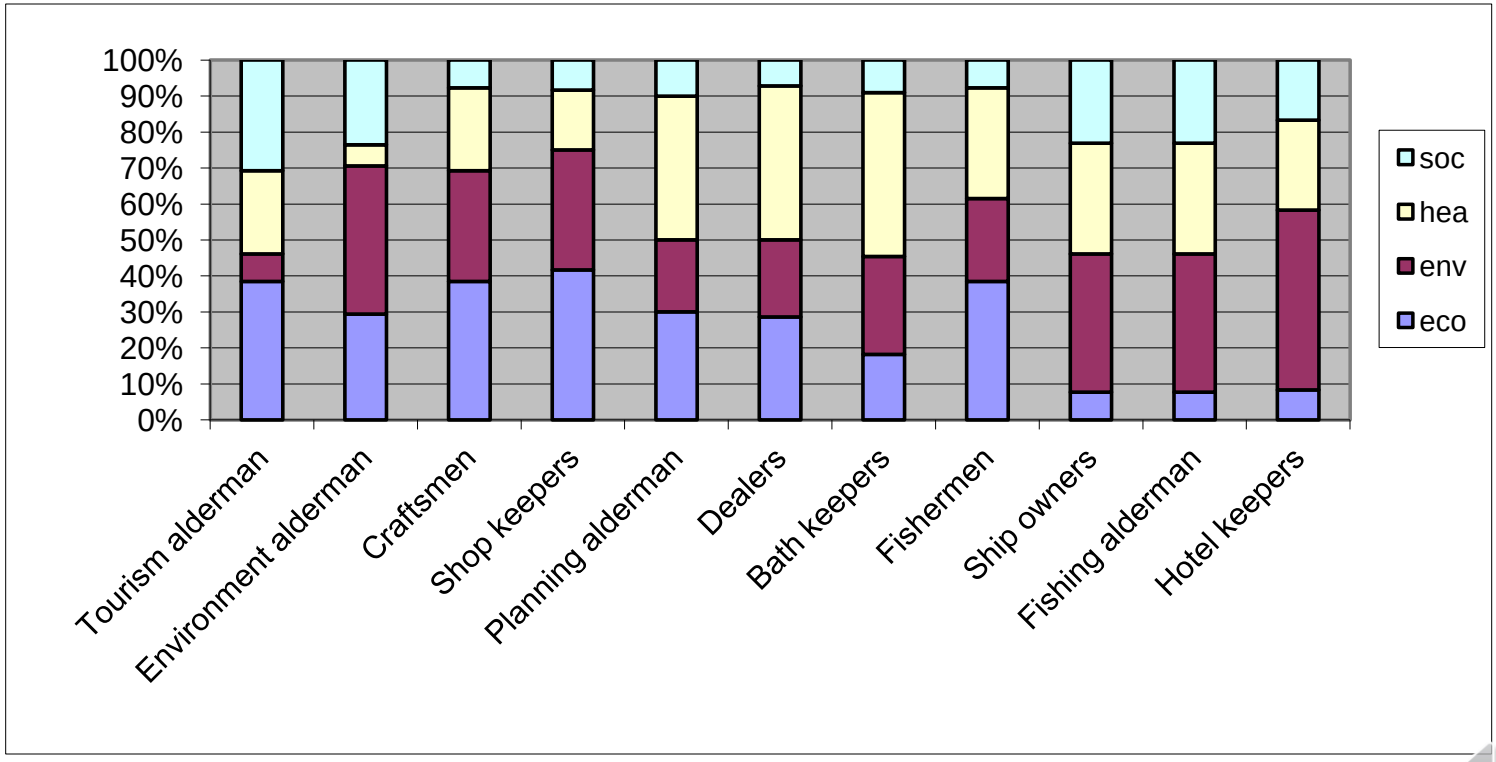
Hydraulic vulnerability map

Risk map

- Combination through multi-criteria analysis
  - Ecological vulnerability map: EVI
  - Social vulnerability map
  - Economic vulnerability map
- Equal weights
- Weights based on the site specific surveys with stakeholders
- Weights decided by the user

Stakeholder perception of damages

- Priorities associated to social, health, environmental and economic damages



Conclusions

- THESEUS project is integrating the most relevant scientific outcomes into
  - design guidelines (to be published by Elsevier in 2014)
  - Special Issue on Coastal Engineering
  - decision support system for coastal risk assessment and management (available at the project website, www.theseusproject.eu).
- This GIS-based tool operating at high spatial resolution allows coastal stakeholders
  - to rapidly assess local risk level,
  - to identify mitigation measures and related reduced impacts,
  - to select and check the challenges of adaptation strategies,
  - to organize early warning and evacuation plans.

Thank you!

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