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Biofuel impacts on ecosystem services, biodiversity and human well-being – *the contribution of SWAT modelling to integrated land use governance*

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SWAT conference, 24-26 June 2015, Pula

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Ecosystem services, biodiversity and human well-being

Ecosystem services are benefits people obtain from ecosystems:

- *Provisioning* (food, fuels, fibre, timber, etc), regulating (flood or pest control, climate regulation),
- *Supporting* (services necessary for the delivery of other services, such as nutrient cycling)
- *Biodiversity* own category or supporting
- *Cultural*

Landscapes provide services which benefit humans

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Governance of land (scapes)

- **Land use and management** influences system processes and structure and thus the provision of services
- **Trade-offs** between ecosystem services
- How should we deal with trade-offs?
- Risk of sub-optimal allocation of land and societal conflict

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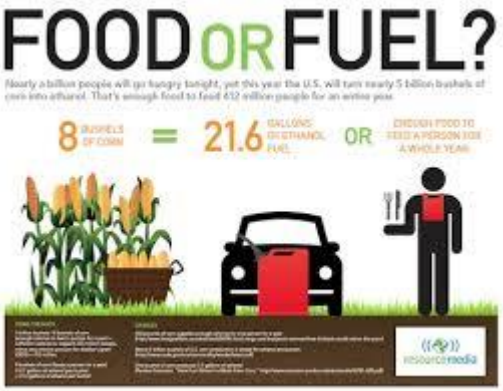
Biofuels

New demands of land for the production of biomass for biofuel can:

+ reduce transport GHG emissions, improve food security, provide development opportunities in rural areas

- compete with food production, and contribute to climate change and biodiversity loss



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ILAMS project

Integrated Land Management Solutions for a Sustainable Bioeconomy

Overall aim: provide tools to promote wider agreement on the role of bioenergy technologies for environmental quality and human well-being

Decision making support tool:

- Landscape assessment of the impacts of biofuel systems on ecosystem services and human well-being
- Simulate alternative scenarios of land use & management

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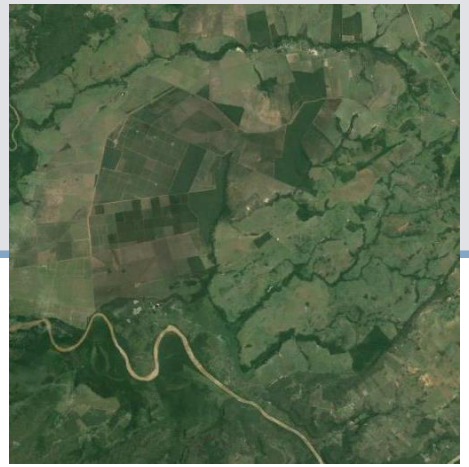
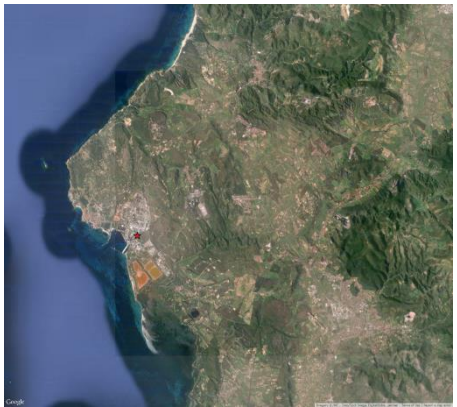
ILAMS - Case studies

1. Biodiesel from soya bean – Mato Grosso, Brazil



2. Ethanol from sweet sorghum – Texas, US

3. Ethanol from giant reed (Arundo Donax) – Sardinia, Italy



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Sardinian case study

Ethanol production unit:

- Biochemtex Technology: second generation ethanol
- 400 kt/y biomass feedstock - 160 kt/y imported wheat straw, and 240 kt/y GR (210 kt/y cultivated)
- Output: 80 kt/y ethanol and 240 kt/y wet lignin

Why Sardinia?

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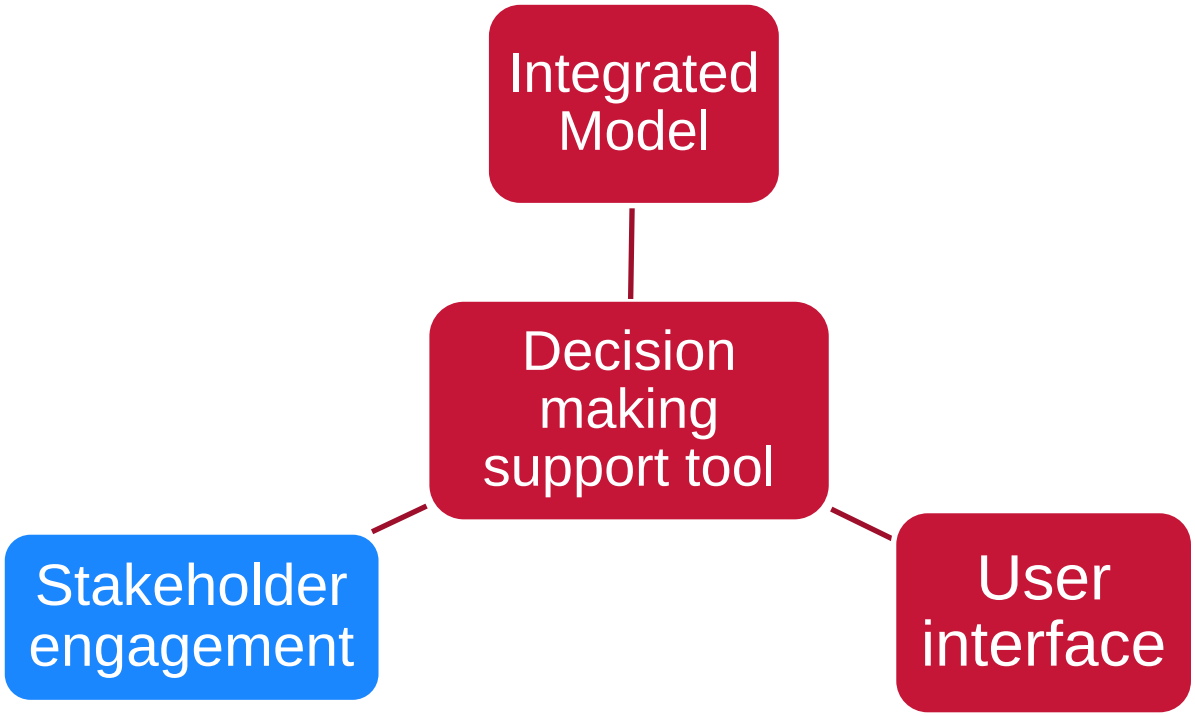

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Stakeholders' engagement

Aim: allow stakeholders to articulate their preferences in relation to biofuel, ecosystem services and human well-being

1. Assessment of stakeholders:
- Key concerns
- Alternative scenarios for land use/management

2. Simulation of scenarios with stakeholders
- Workshop
- Facilitate discussions

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Stakeholders engagement in Sardinia

Biofuel controversial issue


Canne e Sulcis, l'aquila e il pollo


ENERGIA E POLEMICHE

Biofuel, è scontro a tutto campo

L'azienda pone un ultimatum, ambientalisti sul piede di guerra

Wide range of stakeholders

biochemtex

LEGAMBIENTE SARDEGNA

COLDIRETTI FORZA AMICA DEL PAESE

Confagricoltura

Consorzio Bonifica Sardegna Meridionale cbsm

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

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Results of stakeholders assessment

Key concerns

- Water availability
- Food security and production of (high quality) food
- Employment
- Biodiversity

Alternative scenarios

- Irrigation using recycled water WWT
- Use of polluted land (mines/industrial sites)
- Use of marginal land (not cultivated in last 5 years)
- Introduction/expansion of corridors and improved protection of preservation areas

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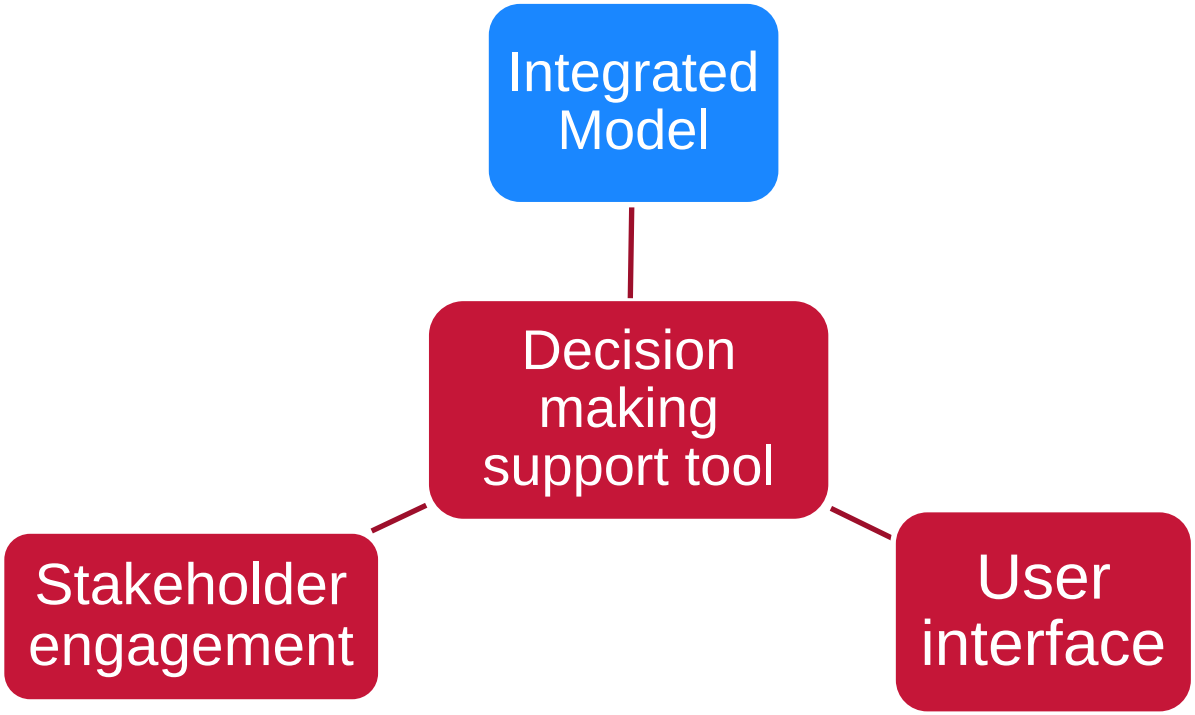

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Integrated model

- Cover all stakeholders' key concerns
- Simulate current status and alternative scenarios of land use/management
- Landscape approach

➢ Use existing models

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Sub-models

1. Biophysical processes module

- SWAT – water availability, crop production, carbon storage
- InVEST habitat quality & MatrixGreen – biodiversity
- InVEST carbon – carbon storage

2. **GHG emissions module**
    - LCA (excel) – GHG emission of biofuel
    - Inventory (excel) – GHG of transport and el/heat in the landscape

3. **Human well-being module**
    - Mass balance model (excel) – food/feed/energy security
    - Employment generation (ArcGIS)
    - Revenues (ArcGIS) – farm revenues

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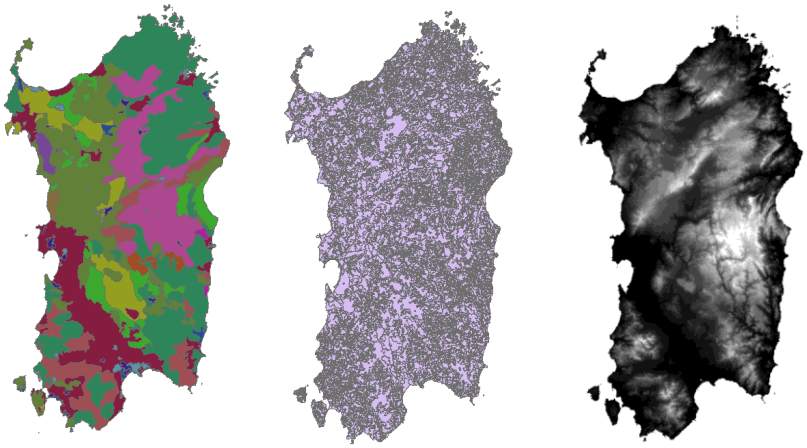
1. SWAT

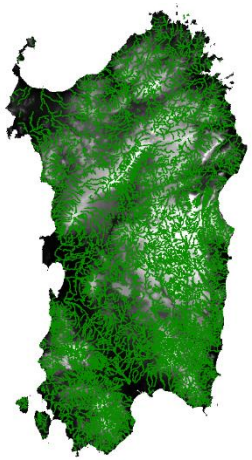
Outputs of interest:

- Water availability
- Crop production
- Carbon storage (biomass above & below ground and DOM)



Data:

- DEM 10m - Sardinia Region
- LULC - CORINE 2011
- Soil - European Soil Database
- Weather - CFSR
- Digitalized river stream network - Sardinia Region



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SWAT - Watershed delineation

Conditions:

- 6000 ha
- Potentially irrigated
- 75km max distance from production unit
- Outside protected areas

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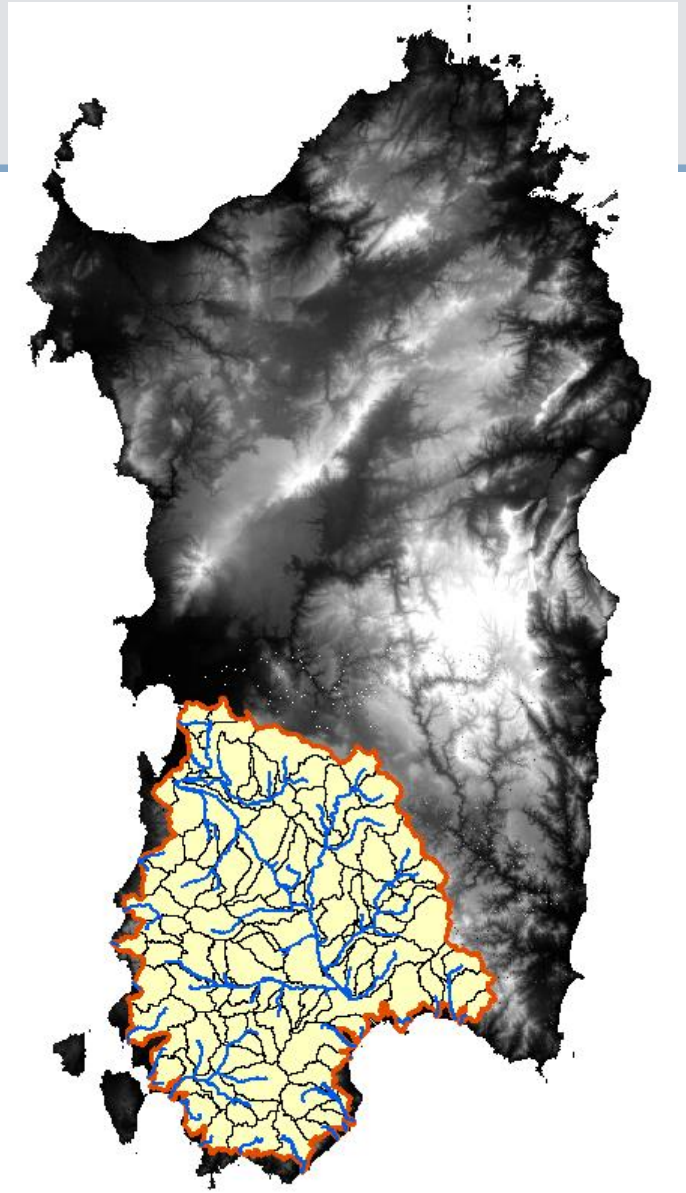
Basin:
550 000 ha
108 subbasins
851 HRS

Land use:
10% forest
12% rangeland
60% agriculture



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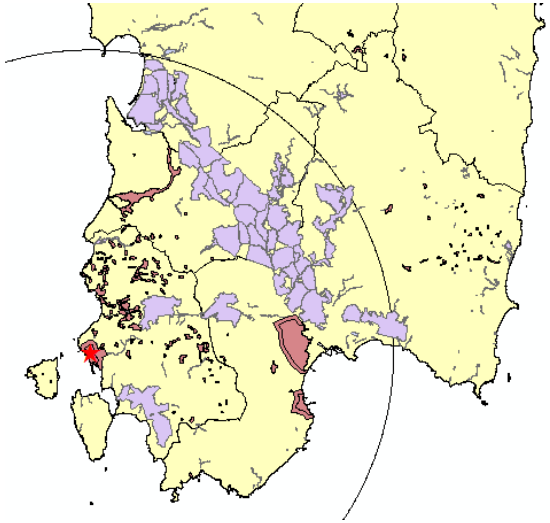
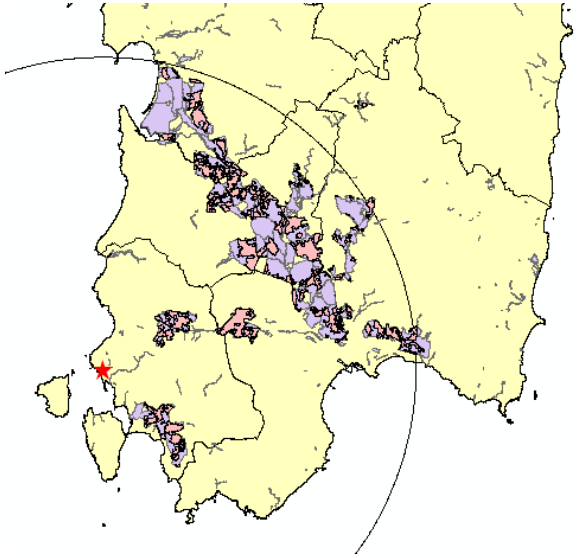
SWAT – ongoing work

- More accurate LULC map
- Land management data
- Data for reservoirs and WWT
- Run and calibrate model
- Prepare alternative scenarios

Polluted land



Abandoned land



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1. InVEST – habitat quality

Habitat quality as an indicator of the status of biodiversity. Areas of high quality are generally better able to maintain biodiversity

Data

- LULC
- Threats (urban&industry, agriculture, roads)
- Habitat accessibility (parks & reserves)
- Habitat sensitivity (grasslands < forests < wetlands)

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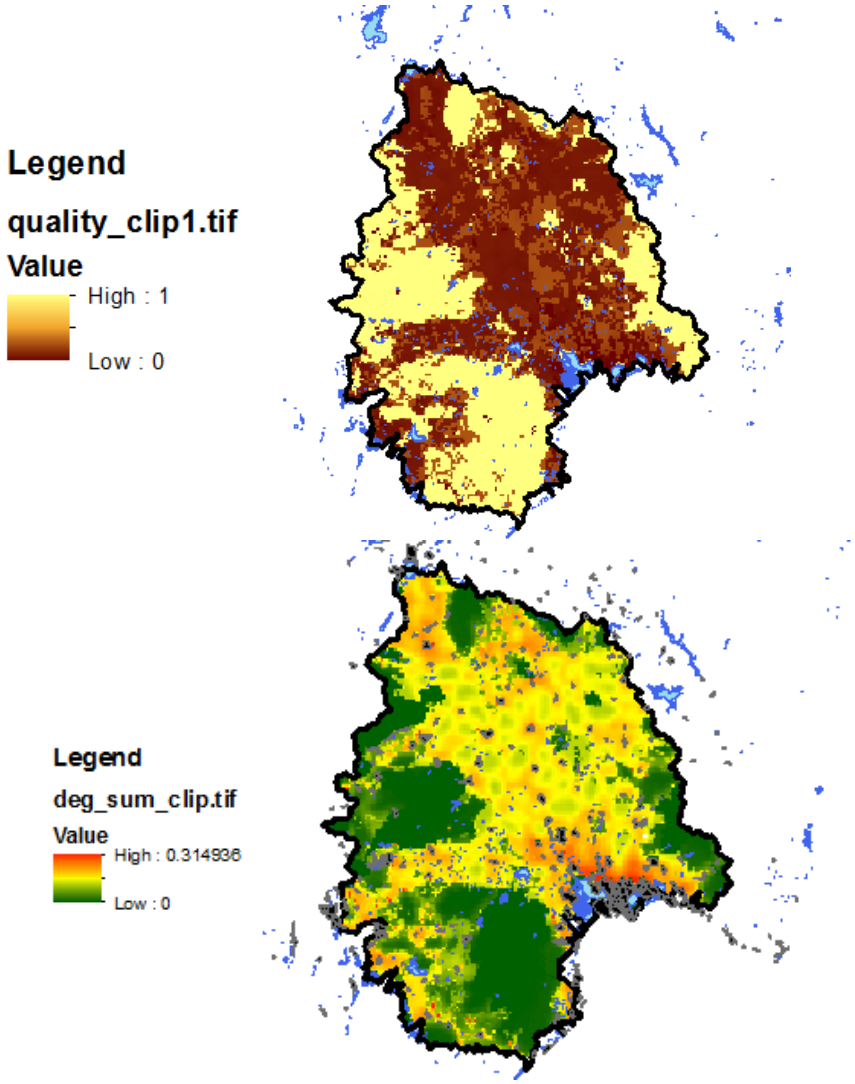
Habitat quality – preliminary results

Habitat quality map

- Quality of habitat
- Proximity to threats

Habitat degradation map

- Distance to threats
- Habitat sensitivity
- Habitat accessibility



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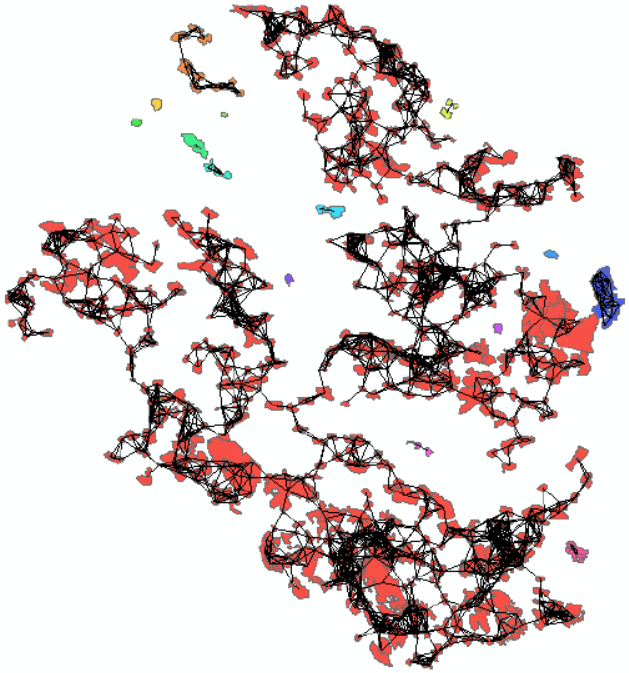
1. MatrixGreen - connectivity

- It models connectivity and spatial distribution of habitats.
- Data: map of habitats
- Component based connectivity
- Outputs: map and total value of habitat connectivity



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1. InVEST – carbon storage (modified)

Storage is the amount of carbon in an ecosystem at any given point in time

Carbon stock as a function of land use/land cover

Data:

- LULC
- Carbon coefficients for each LULC class

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1. Carbon storage

4 carbon pools:

- Above ground biomass
- Below ground biomass
- Dead Organic Matter
- Soil Carbon

Carbon coefficients

Table of carbon pools

(metric tons / hectare)

LULC	LULC_name	C_above	C_below	C_soil	C_dead
1	Forest	140	70	35	12
2	Coffee	65	40	25	6
3	Pasture/grass	15	35	30	4
4	Shrub/undergrowth	30	30	30	13
5	Open/urban	5	5	15	2

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2. GHG emissions – biofuel LCA

- Impact of the project on GHG emissions of the area
- Production of biofuels generates GHG credits

Functional Unit	**Global Warming Potential/GWP100 ($kgCO_2$-eq)**
Per 1 ton of bioethanol	4.5
Per 1 ton_{dry} of *Arundo donax*	0.9
Per 1 hectare	22.6
Per 1 year (total emissions)	181178
GHG savings from petrol	99.3%

- Incl. cultivation, harvest, transport and transformation
- Exclude LUC

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3. Human well-being - Security

- Security as physical availability of water, food, feed and energy
- Mass balance for the watershed
- Excel files

Water

Availability from SWAT results

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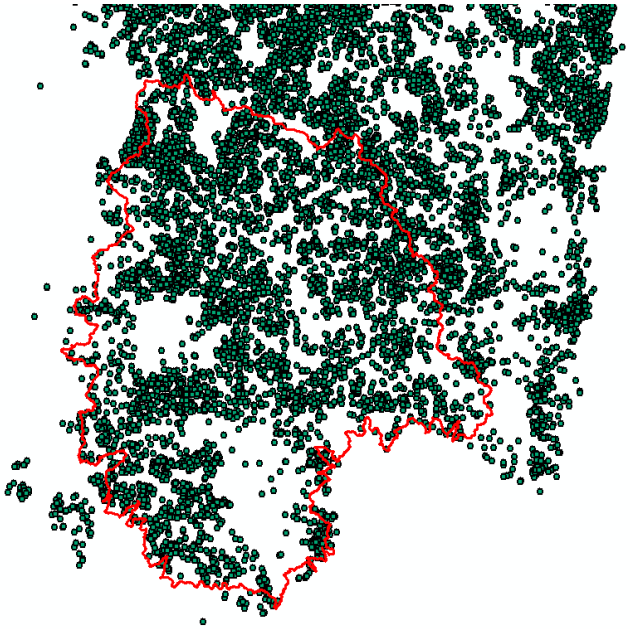
3. Human well-being - Security

Food security

- Supply: crop production (SWAT) + animal production data (milk & meat)



- Consumption per family/person: food statistics for the region

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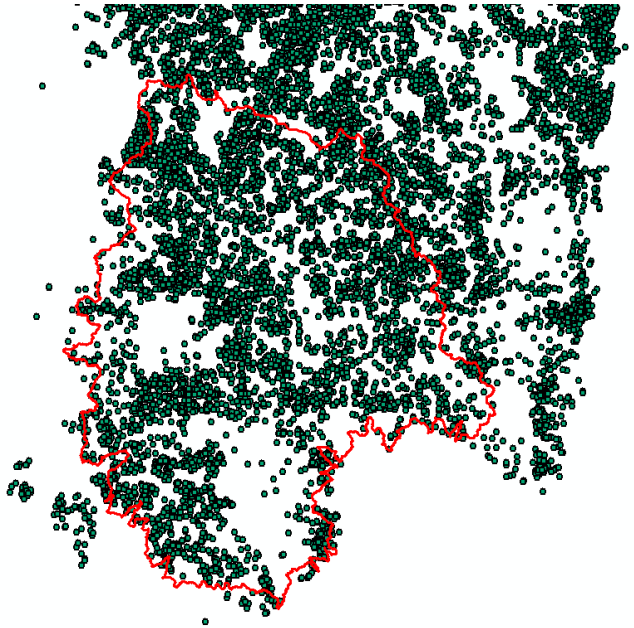
3. Human well-being - Security

Feed security

- Supply: feed production from pasture, rangeland, crops (SWAT)

- Consumption: number of animals (cows, goats/sheep and pigs) and intake coefficients



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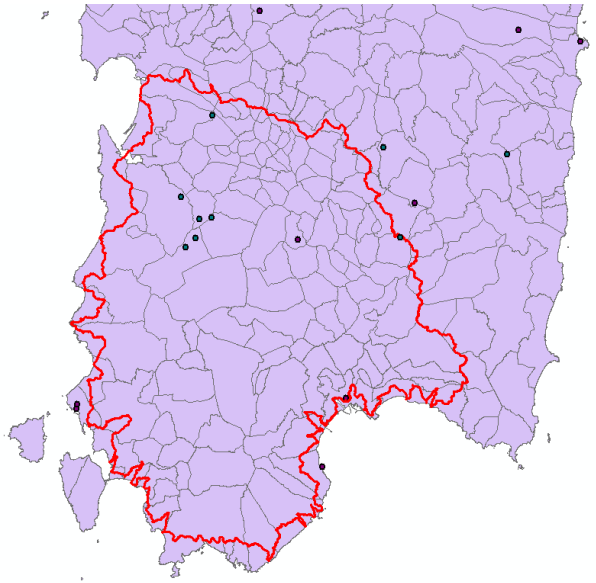
3. Human well-being - Security

Energy security

- Supply: energy provided from resources within watershed (coal, wind, solar & biomass)



- Consumption: energy used for transport, el/heat per person, or ha within watershed

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Employment generation

Employment

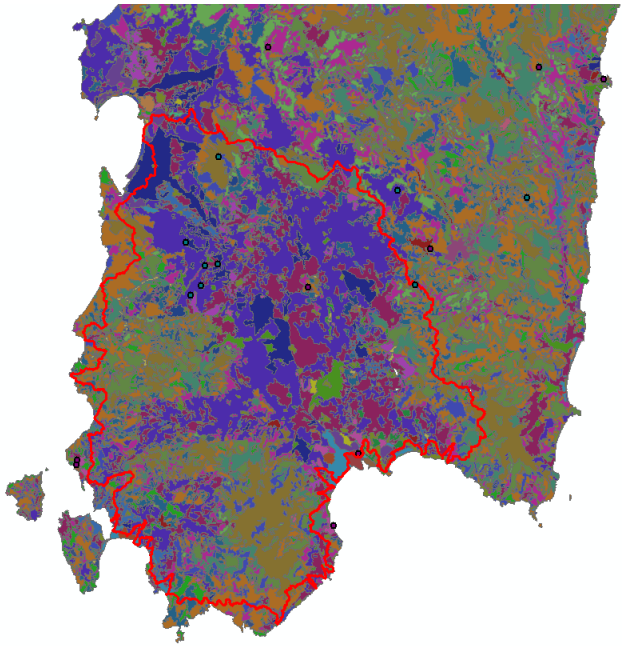
- Agricultural employment coefficients
- Agricultural employment GR for cultivation, harvest, transport (Beta Renewables data for subcontractor)

Allegato J - Tabella regionale del fabbisogno di manodopera in agricoltura

A) Fabbisogno di manodopera per coltura

Coltivazioni erbacee ed orticole	h/uomo per ha
Frumento, orzo, avena	48
Mais da granella	64
Altre leguminose da granella	64
Soia	40
Silomais	45
Sulla	47
Erbai in asciutto	34

Coltivazioni erbacee ed orticole	h/uomo per ha
Altre piante officinali	880
Fragola in tunnel	3360
Anguria	468
Melone	576
Fiori in pieno campo	4920
Fiori in serra	9200



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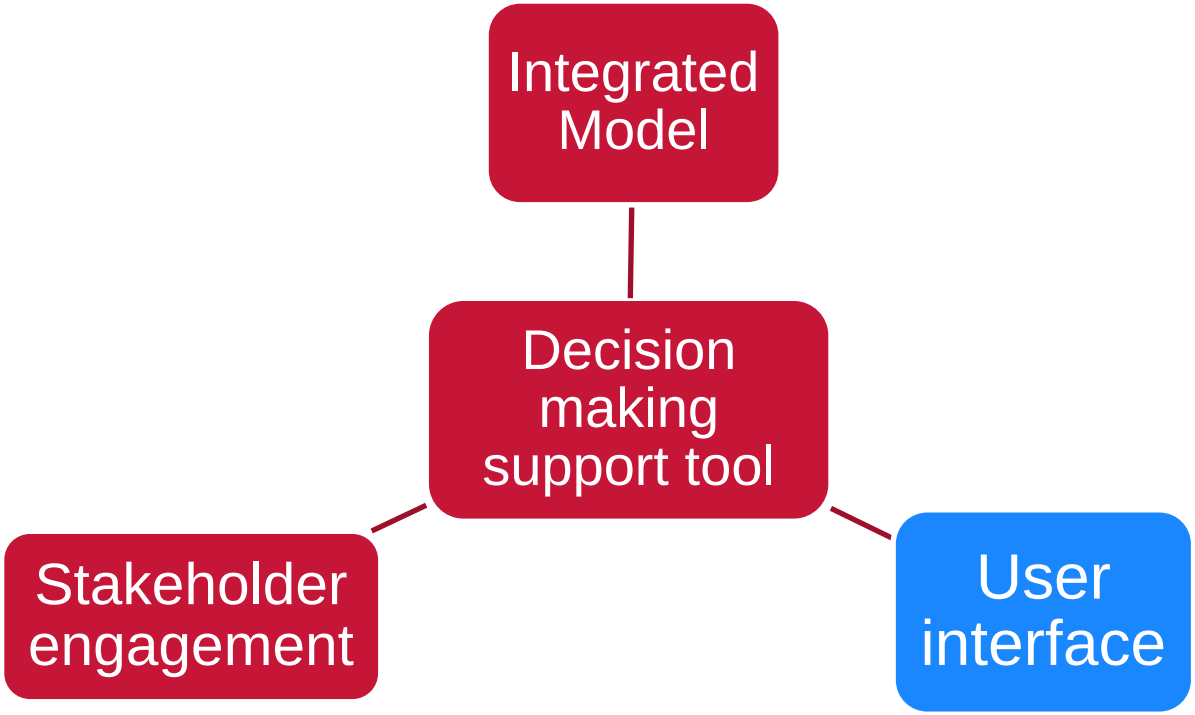

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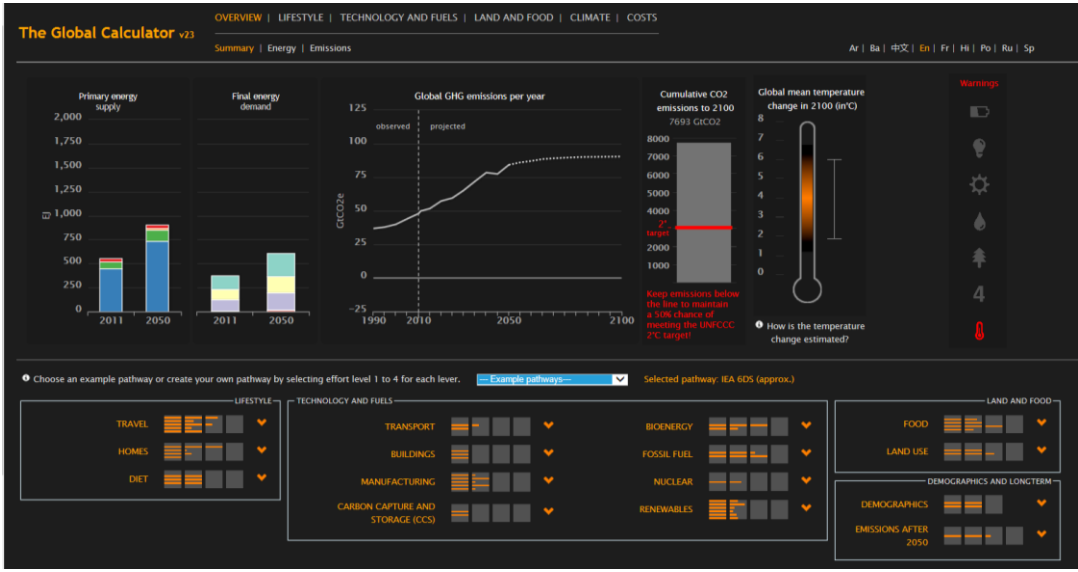
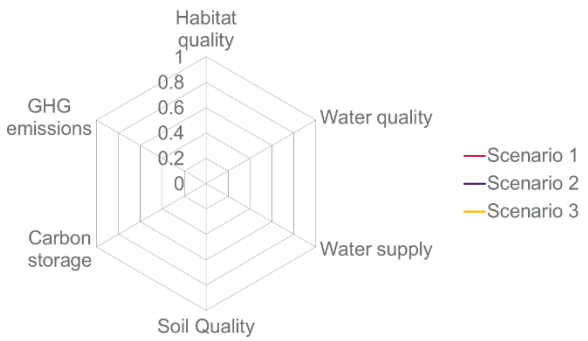
User interface

- Allow users to simulate scenarios
- Simple, transparent and responsive to end-user needs
- Information on the spatial distribution of ecosystem services
- Understanding of trade-offs and win-win opportunities





Example [The Global Calculator]

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Conclusions

- **Modelling** is a tool that can be used to build consensus about biofuels, minimizing conflicts and improving project outcomes
- It requires **knowledge integration** - biophysical, technical and social aspects
- SWAT can be used with other models to provide a comprehensive understanding of biofuel impacts at landscape level

Thank you for the attention!