Energy planning decision making tools: the importance of geographical information

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Presentation content

- Geographical Information System
- GIS and renewable energies
- Planning methodologies and tools
- AFRETEP tool

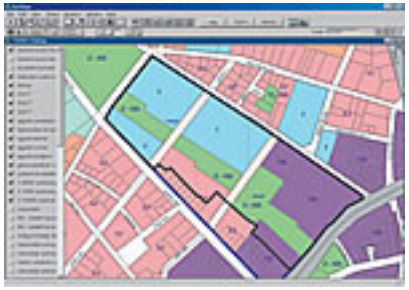
What is a GIS?

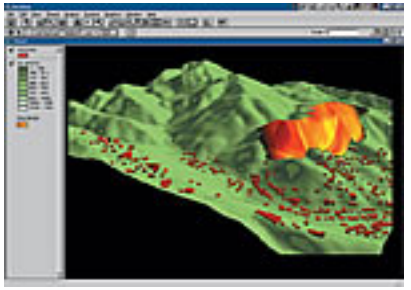
We use **GIS application** to deal with **spatial information** on a computer.
GIS stands for **'Geographical Information System'**.
A GIS consists of:

- **Digital Data** – the geographical information that you will view and analyze using computer hardware and software.
- **Computer Hardware** – computers used for storing data, displaying graphics and processing data.
- **Computer Software** – computer programs that run on the computer hardware and allow you to work with digital data. A software program that forms part of the GIS is called a GIS Application.

What can we do with it?

Location	What is….?
Condition	Where can it is true that...?
Trends	What has changed since…?
Routes	What is the optimun route..?
Pattern	What spatial pattern exists…?
Modelling	What if…?



GIS: functions and tools

Input: To capture, import data

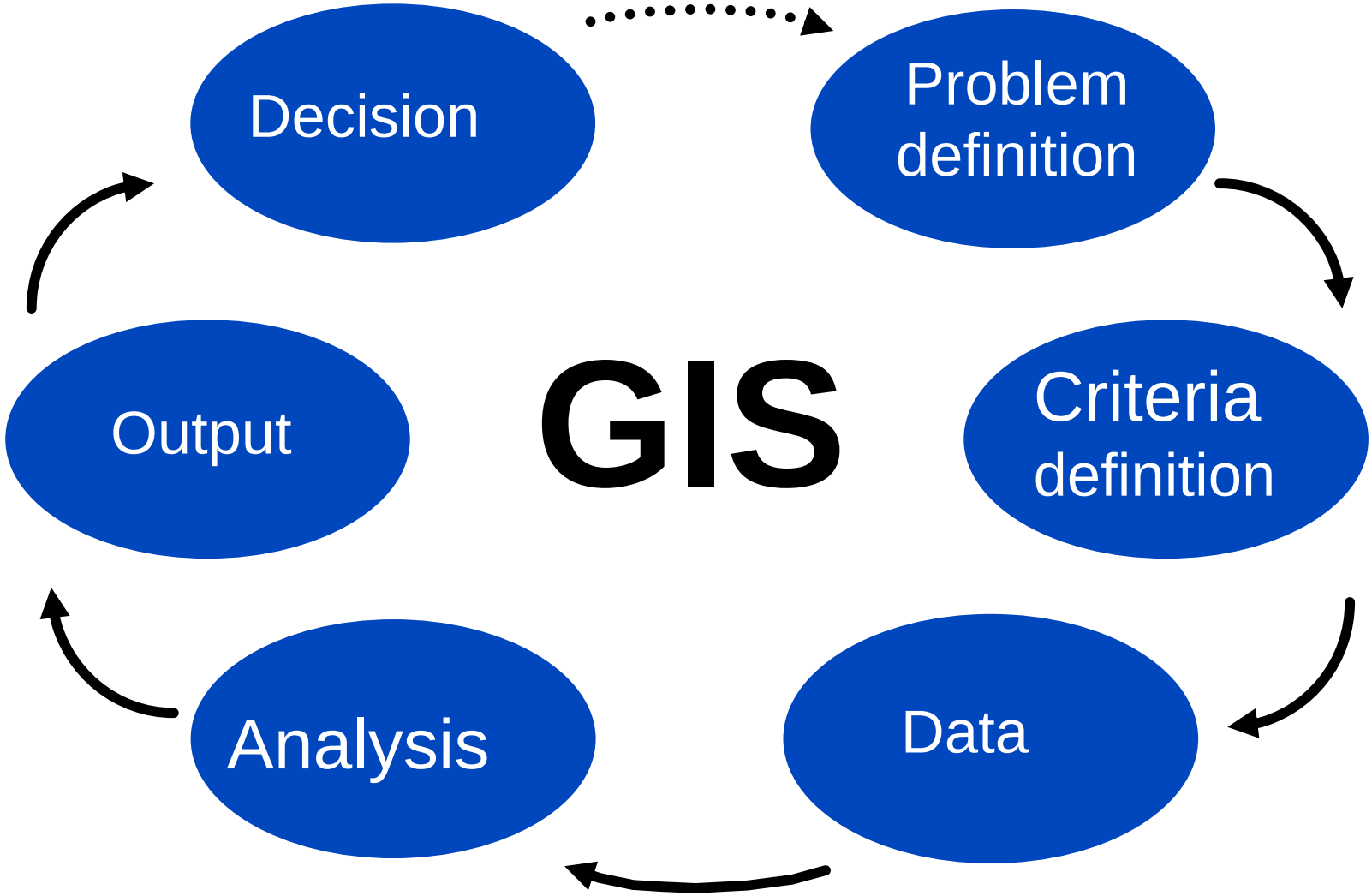
To digitalise

Management: To organise and extract information

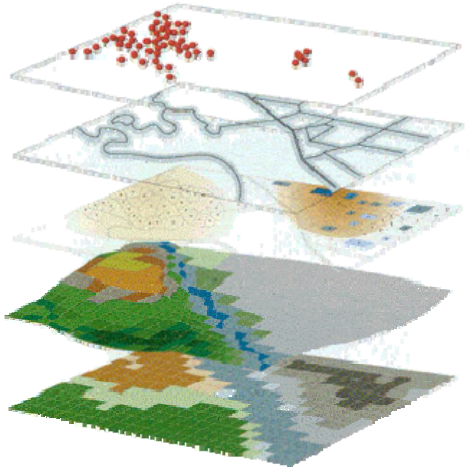
Analysis: To process and create new information from the data.

Output: To show the results to the user, to print out a map

Working flow



Geographical data



(Probably) greatest cost in GIS analysis (both money and time!)

Results rely on the quality of the input data: fiability and scale

Data is heterogenous: produced by diferent organisms, following different methods

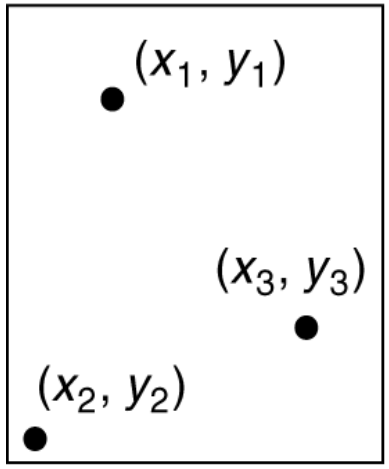
Data, within GIS, is structured in layers

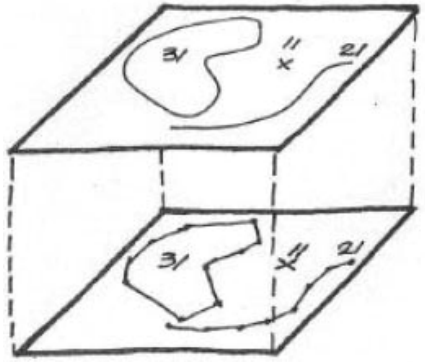
2 data models: vector and raster

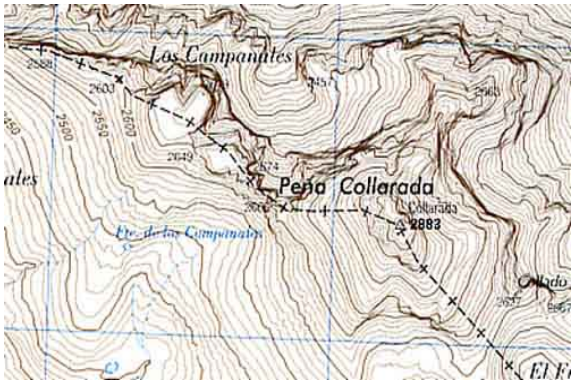
Data model (I)

Vector model

- Discrete elements, well defined shapes
- Point: minimum unit
- Structure: XY coordinates.
- Points: trees, meteorological stations, elevation points meteorológicas, ...
- Lines: roads, rivers,...
- Area: crops, soil types,…



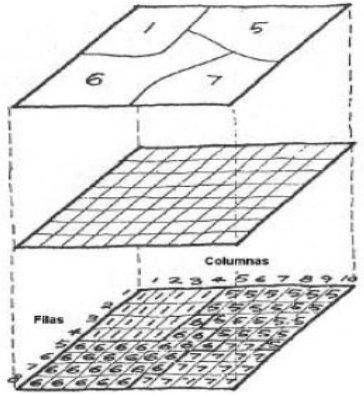


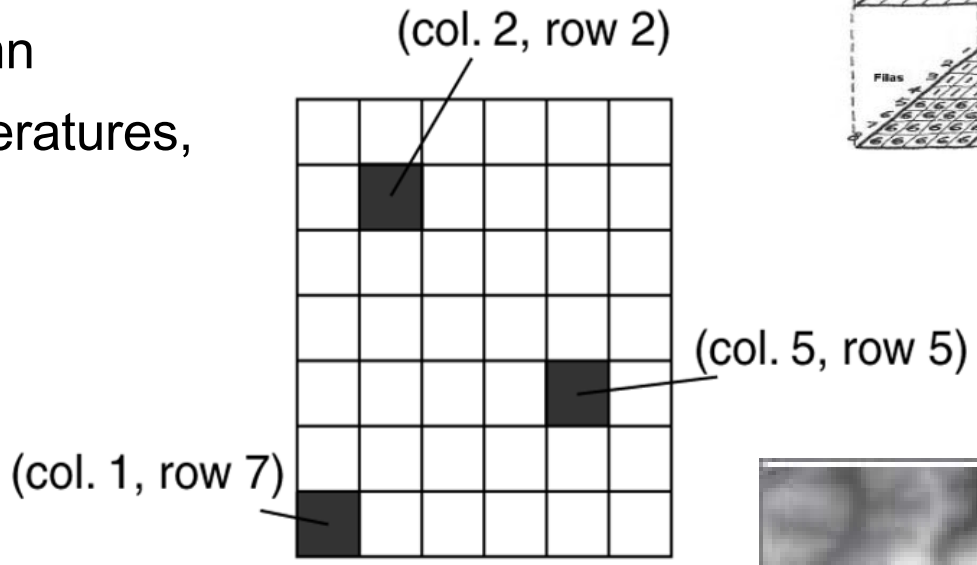


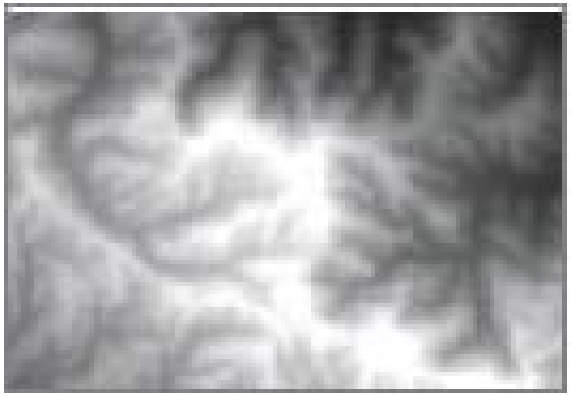
Data model (I)

Raster model

- Continuous elements: limits don´t matter, what matters is variation
- Cell or pixel: minimun unit.
- Structure: row/column
- Precipitations, temperatures, altitude,…

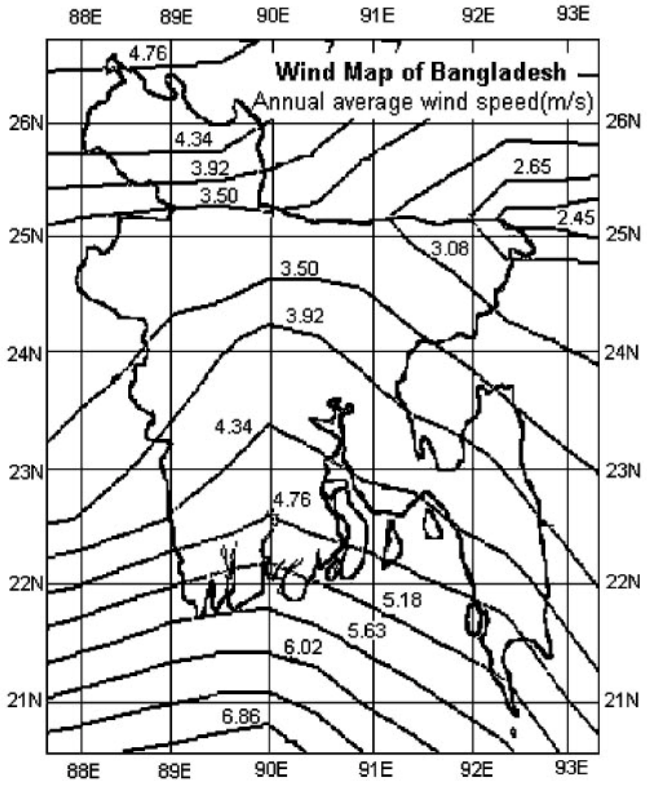






Wind energy

Resource evaluation and optimal location
DEM (great influence of topografic factors) and SW to evaluate resource (WAsP)



Khan (2004)

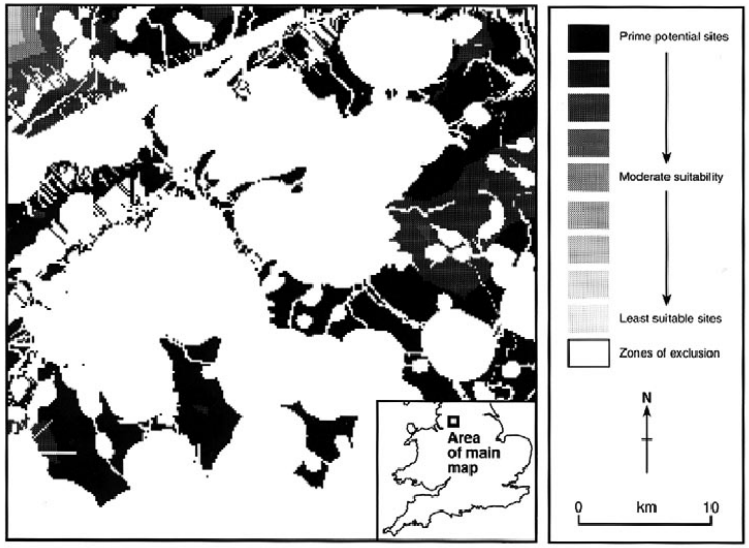
Bangladesh

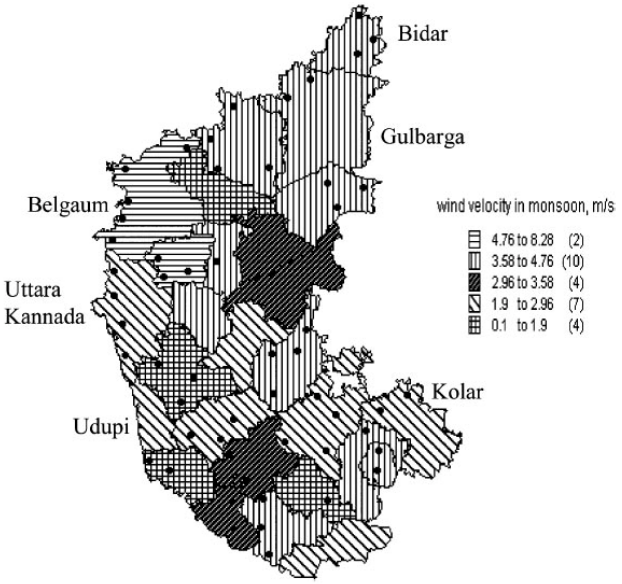
Uses microscale elements (terrain roughness, elevation) in mesoscale models.

Results: medium scale wind maps

Fig: average speed at 30m map

Wind energy





Baban (2001)

United Kigdom

Based on survey

14 thematic layers

Results: 10 classes (excluded in white)

Ramachandra (2005)

India

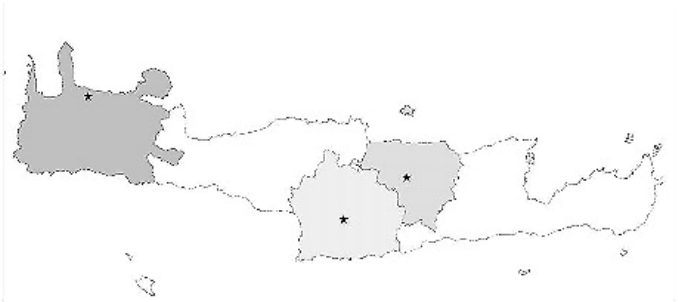
Quantifies estational diferences

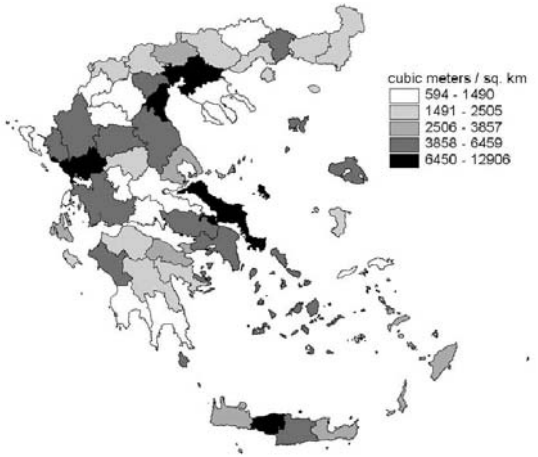
Prevailing winds, near by terrain, vegetation, proximity to residential areas,..

Fig: wind variation during monsoon

Biomass

Economic feasiblility greatly influenced by geographical factors (resource availability, transport,…)





Voivontas (2001)

Crete

Biomass potentital for energy generation

Included resource evaluation, transport costs, optimised location for energy crops, optimised location for treatment and energy generation plants

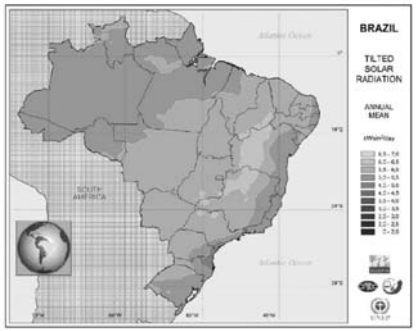
Batzias (2005)

Greece

Animal residues and manure for biogas production

Calculation based on data from 1970-1998 regarding cattle numbers, availability and energetic factors

Solar energy

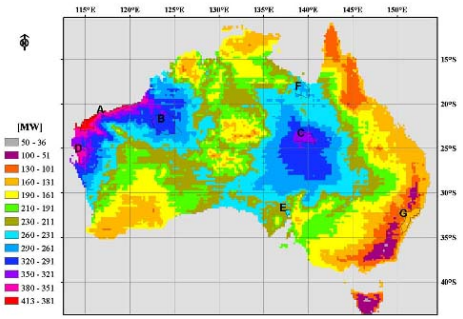


Martins (2006)

Brazil

Solar radiation maps based satellite imagery, following NREL model

Fig: Anual average of global radiation on tilted surface

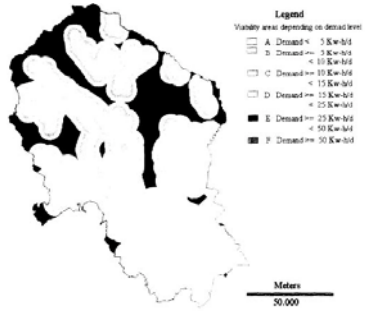


Altmann (2005)

Australia

Assesses the potential instalation of solar tower, using topographic and meteorological parameters.

Fig: estimated production in MW.



Ariza (1997)

Spain

PV off grid systems competitivenes in remote areas

For domestic demand (5kWh/day), PV systems turned to be competitive in 69% of the region area.

Energy planning

- Decision-makers face problems in which a multitude of conflicting goals exist.
- Goals need to be established and prioritized-> decision variables and relations among them.
- Decision support system: Assist the decision maker in exploring and evaluating alternative courses of action

Decision process

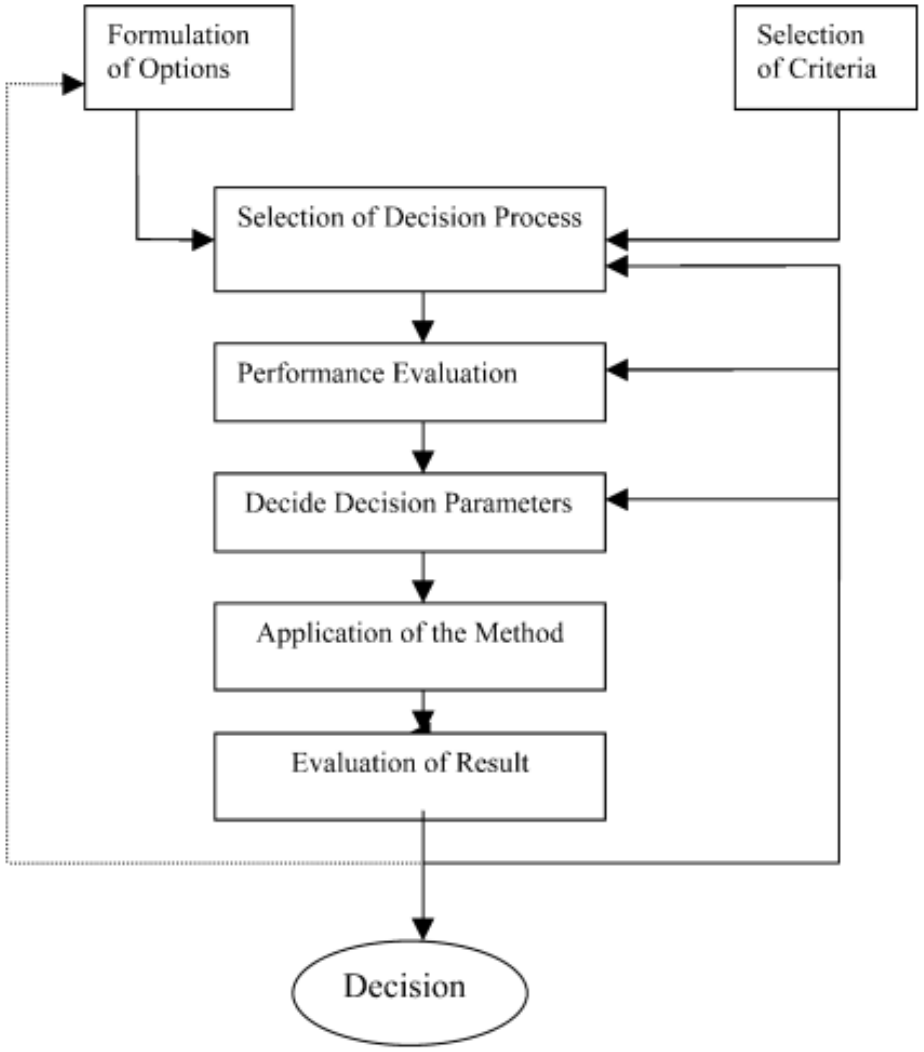


Fig. 1. Multicriteria decision process.

- Objective to be achieved (coverage rate, access rate, penetration rate, etc.)
- Constrains (political, technical, financial, other,…)

Pohekar, S. D. and M. Ramachandran (2004). "Application of multi-criteria decision making to sustainable energy planning--A review." Renewable and Sustainable Energy Reviews **8(4): 365-381.**

Planning methods

- Who decides? (national power utility? Goverment? Private company?)
- What is the goal?
  - Achivement of MDGs
  - Impact of RE on poverty alleviation
  - Sustainability
- Where?
- When? Time horizon?
- Spatial dimension influences the optimisation process

Spatial dimension

- Supply (grid, renewable resources availability), demand (type of demand, localisation, density, settlement pattern,…) and its linkage is based on spatial expression.
- Transmission lines
- Social/economic characteristics: development poles / catchment areas.

Planning methods

- Models and tools-> interpretation of reality, approximation!
- '*One solution fits all*'?

- Categorization is delicate: Policy making, investment planning, project identification, project (grid extension) design
- Suggested:
  - "Supply-based" methods: traditional approaches, existing power infraestructure as the main input
  - "Demand-based" methods: demand is given more importance and viewed as energy services, not merely kWhs

Supply-based

- Resource planning:
  - Identifying least-cost production and demand side management strategies
  - The potential of certain energy sources
  - The influence of new regulations (taxes, tariffs)
  - Traditionally undertaken by national power utilities

Supply-based

- Distribution planning:
  - Optimising MV & LV line routes and substation locations of the national grid to minimise costs to meet demand

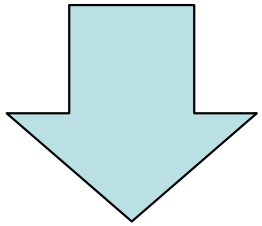
Demand-based

- Integrated Territorial Planning
  - Aims at identifying different types of projects on a give territory in order to define the least-cost and most appropriate solution to meet rural demand.
  - Principles:
    - Technological neutrality
    - Focus on the most relevant end-uses from the point of view of socio economic impact
    - Multisectoral approach (water access, education, health planning)
    - Priority targets (restrictive selection, weighted , kWh weighting depending on use)

Sofware tools

- Sizing production options
- Sizing networks
- Territorial planning

- Point
- Line
- Area

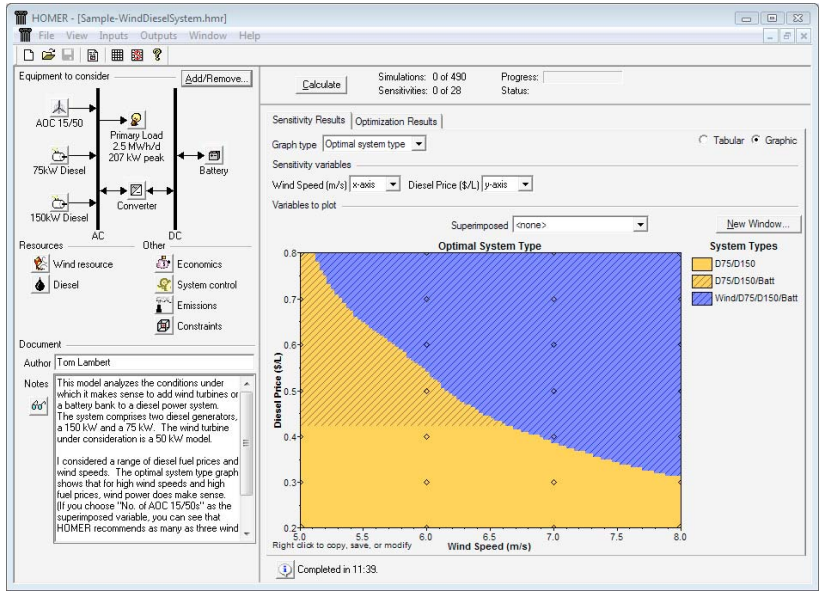


Data?

Scale?

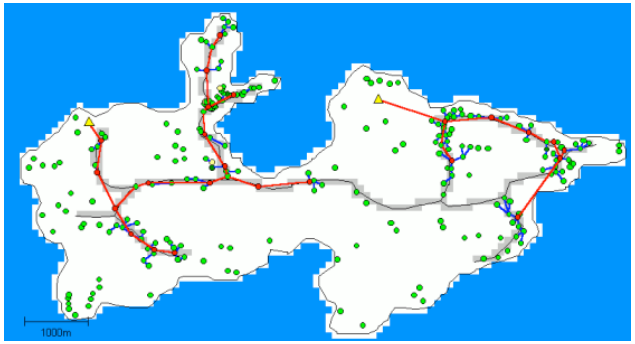
SW Tools

- HOMER (NREL)
  - Technical and economic feasibility or isolated inerconnected renewable energy systems
  - Assessment of hybrid solutions
- RETScreen (NRCan)
  - Sizing and costing renewable energy and energy efficienvy projects
- PVGIS (JRC, EC) ☺



SW Tools

- ViPOR (NREL)
  - Optimisation of village power distribution network (LV & isolated solutions)
- LAP (EDF)
  - Low voltage design (current, tension, losses, etc.)
  - Least cost optimisation
- CART (U. Johannesburg)
  - Eskom “Electricity for all”, 1993



SW Tools

- Electrification Planning Decision Tool (RAPS)
  - South Africa
  - Weighting of kWh according to end uses (priority?)
- LAPER (EDF)
  - Least cost master plan
  - Political and evironmental criteria
- GEOSIM (IED)
  - Evaluation of impact of RE on local development
  - MV route optimisation
  - Grid and off grid least cost simulations

AFRETEP: tool

- Under development
- *Aim*: to develop a comprehensive analytical tool that can be utilized to evaluate the energy capability and economic viability of off-grid technologies in providing electricity services to remote rural households in Africa.
- Characteristics:
  - Interactive easy-to-use tool accessible through the internet.
  - Continental coverage
  - Barriers: data? Appropriate for regional/local case studies?

What if?

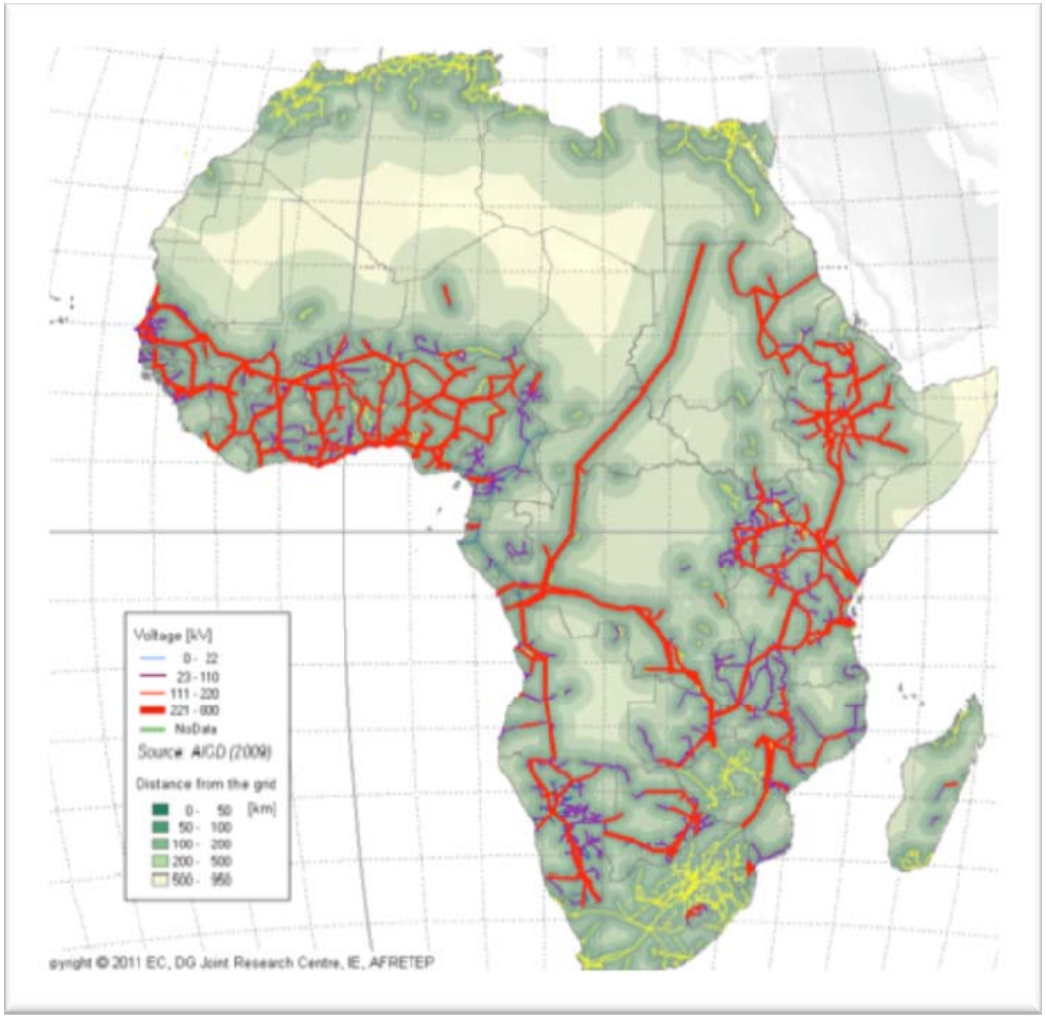
- Assumptions change?
- Other alternatives need to be evaluated?
- Better data is received?

AFRETEP: GIS data collection

- Populated places and population density

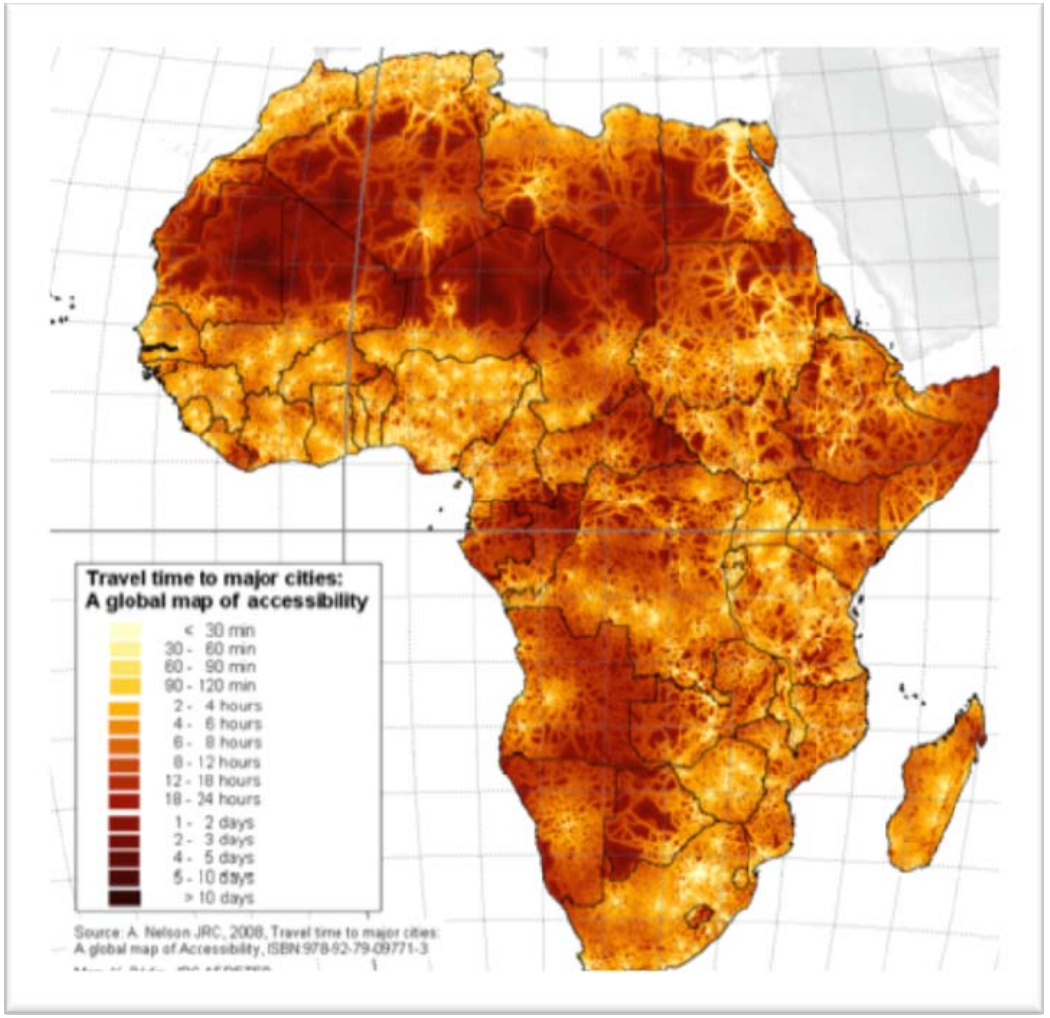
AFRETEP: GIS data collection

- Network distribution



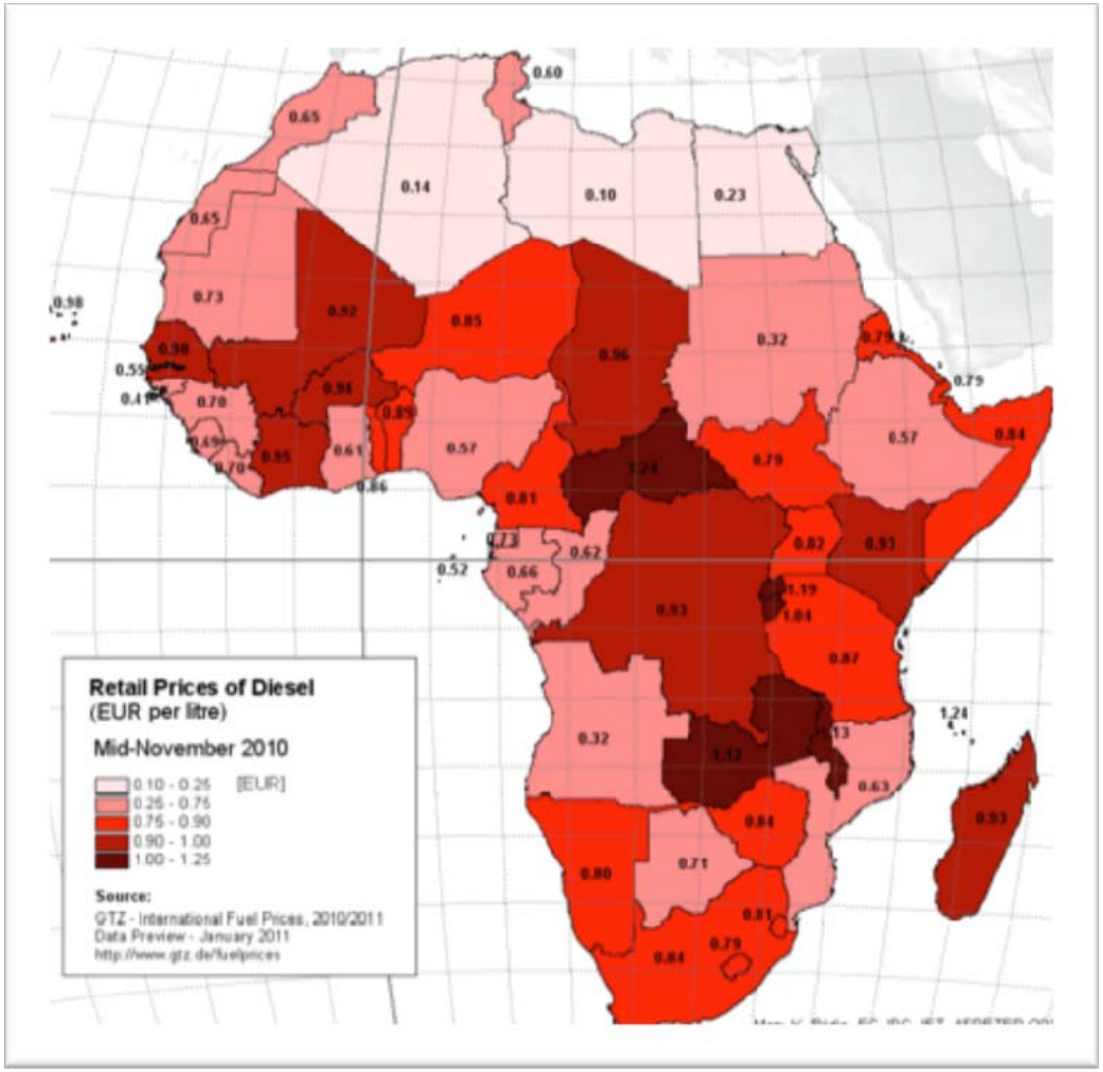
AFRETEP: GIS data collection

- Travel distance



AFRETEP: GIS data collection

- Diesel prices, 2010



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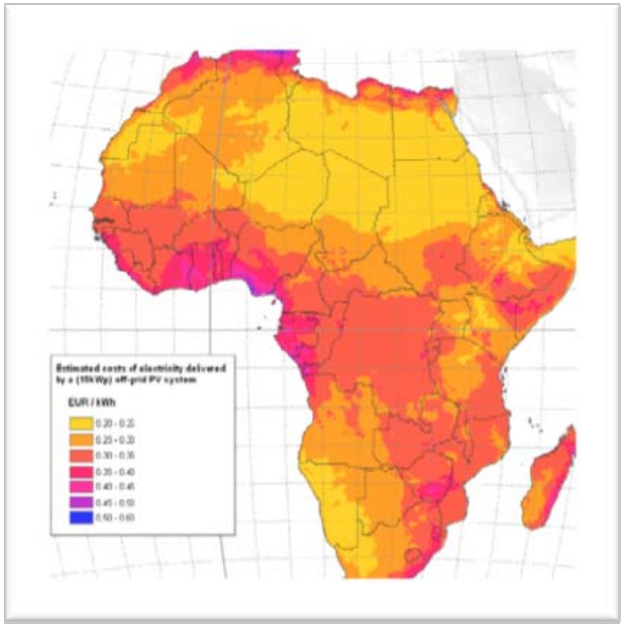
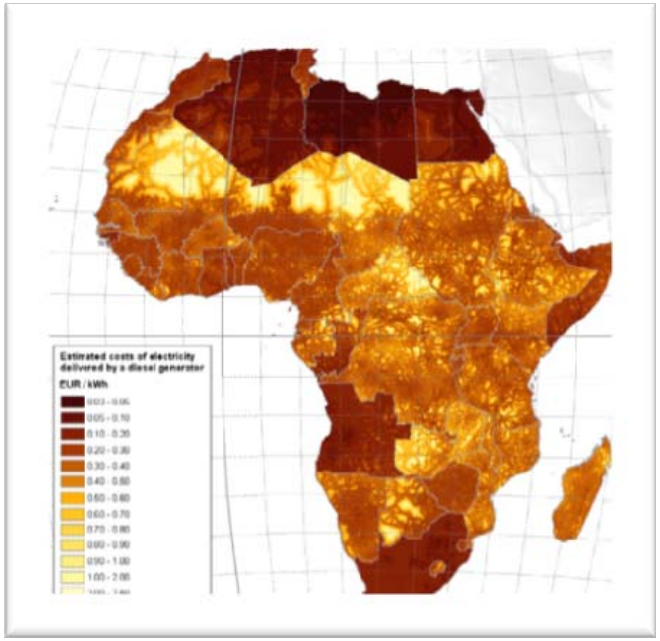
iet
Institute for Energy and Transport

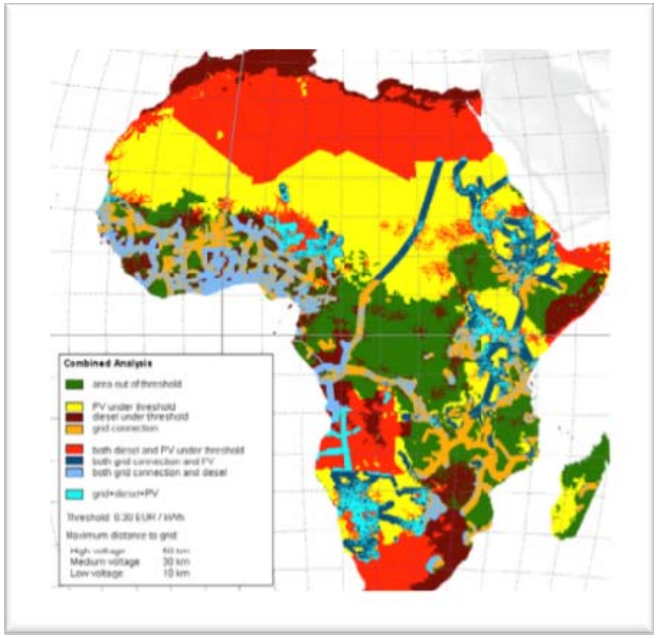
University of Cape Town
Energy Research Centre

What can we model?

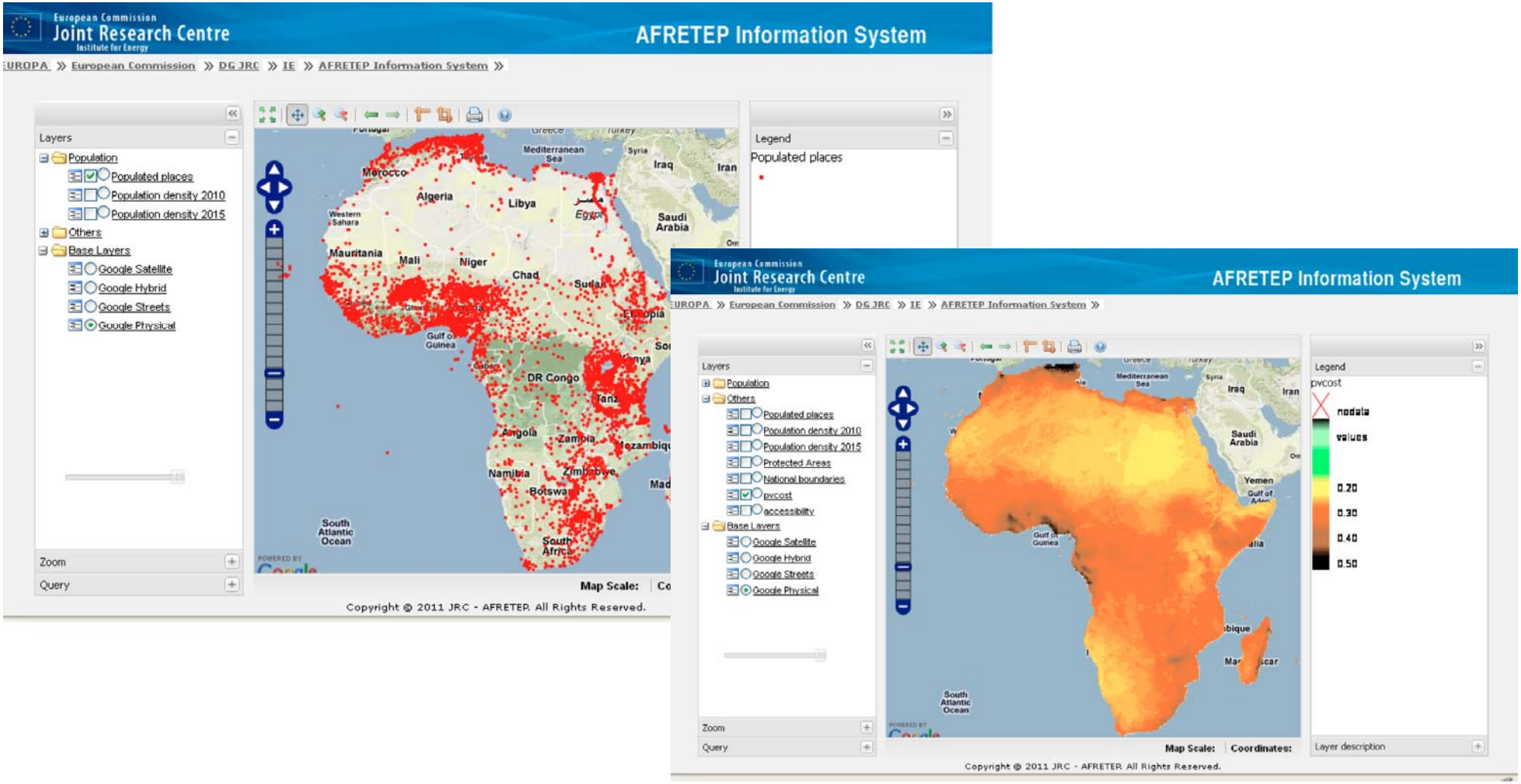
- PV electricity cost, diesel minigrid cost, minihydro, ...
- Not just technological feasibility, but also social/sustainable feasibility (ATP!)
- Uncertainties?







AFRETEP tool



Thanks!!!

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