Integration of ELECTRE TRI in a GIS Methodology and Implementation

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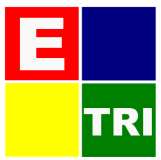
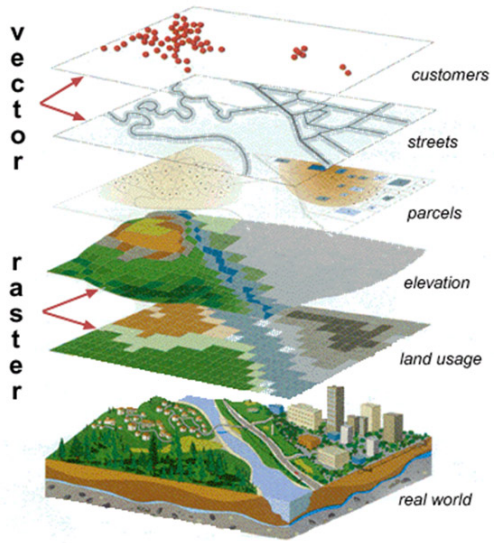
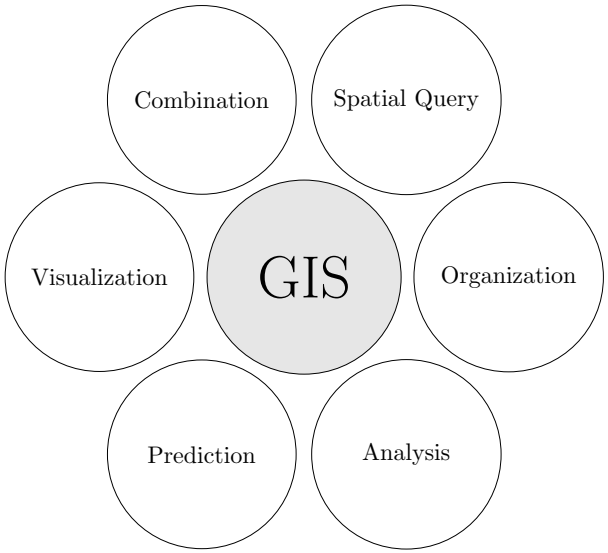


GIS and MCDA

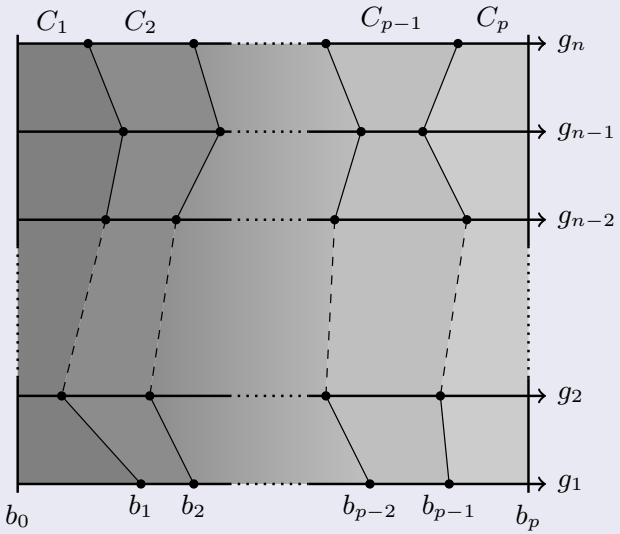




- GIS are used in lot of application from land suitability problem to geomarketing
- Since 90's, works about GIS and MCDA
- Not a lot of work based on ELECTRE methods
- ELECTRE methods fit well for ordinal problems

ELECTRE TRI

Assignment problematic



- p categories
- n criteria

Major interests

- Judge an action independently from the others
- Reference values fixed : profiles
- Allow to consider more actions than other ELECTRE methods

Objectives

Main goal

Implement ELECTRE TRI in an Open Source GIS to facilitate the study of multicriteria spatial problems

Requirements

- Use GIS capabilities to represent the problem and the result
- User friendly
- Support for classic and Bouyssou-Marchant ELECTRE TRI models

Strategy of integration

Reference

- Chakhar's thesis (2006)

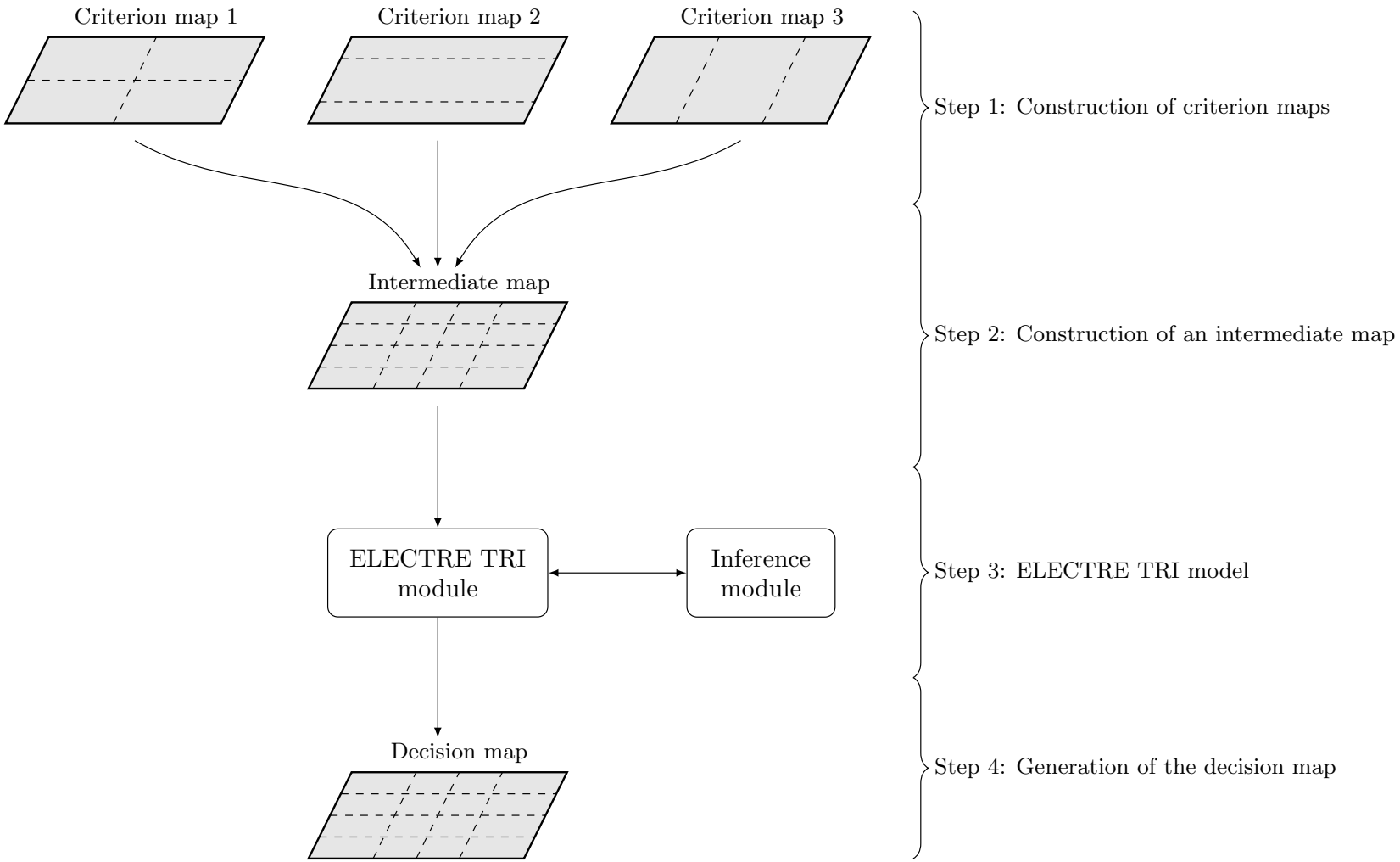
Coupling strategy

- Malczewski (2006) reports only 10 % of works using a strategy of full coupling of the MCDA method in the GIS
- Full coupling

Actions

- Vector layer
- Represented by spatial units on the map (Points, lines, polygons)

Construction of the decision map



Step 1 : Construction of criterion maps

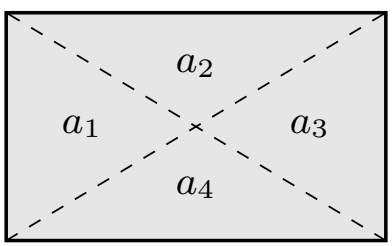
Definition

A criterion map c_j is a set $\{(s, g_j(s)) : s \in S_j\}$ where S_j is a set of spatial units and g_j a criterion function associated to c_j and defined as :

$$\begin{array}{rcccc} g_j & : & S_j & \rightarrow & E \\ & & s & \rightarrow & g_j(s) \end{array}$$

Built with the GIS map algebra

Criterion map



Obj.	Attr. A
a_1	12
a_2	32
a_3	21
a_4	54

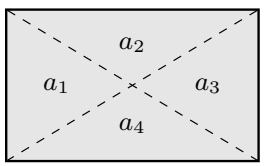
Step 2 : Construction of an intermediate map

Definition

An intermediate map is a map where each spatial unit is associated to a vector of *n* evaluations relative to the *n* criteria of evaluation.

Built using GIS *union* operation

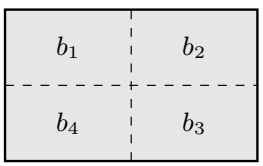
Map A



Obj.	Attr. A
a_1	12
a_2	32
a_3	21
a_4	54

$\oplus$

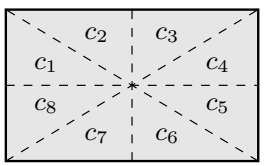
Map B



Obj.	Attr. B
b_1	1.3
b_2	2.4
b_3	3.0
b_4	2.6

$=$

Map C



Obj.	Attributes A	B
c_1	12	1.3
c_2	32	1.3
c_3	32	2.4
c_4	21	2.4
c_5	21	3.0
c_6	54	3.0
c_7	54	2.6
c_8	12	2.6

Step 3 : ELECTRE TRI module

Goal

Introduction of ELECTRE TRI parameters

Parameters

- Weights of criteria
- Reference profiles
- Profiles thresholds (indifference, preference, veto)
- Assignment procedure and cutting level

Inference module

From assignment of some spatial units made by the decision maker, determine the parameters of the ELECTRE TRI model

Step 4 : Generation of decision map

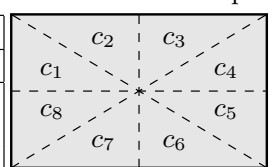
Definition

A decision map M is a set $\{(u, \Gamma_\omega(u)) : u \in U, \omega \in \Omega\}$, where U is a set of homogeneous spatial unities and Γ_ω is a multicriteria classification model defined as :

$$\begin{array}{rcccl} \Gamma_\omega & : & U & \rightarrow & E \\ & & u & \rightarrow & \Gamma_\omega[g_1(u), \ldots, g_m(u)] \end{array}$$

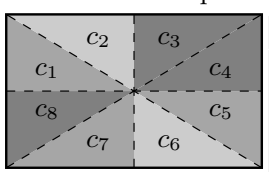
Obj.	Attributes A	B
c_1	12	1.3
c_2	32	1.3
c_3	32	2.4
c_4	21	2.4
c_5	21	3.0
c_6	54	3.0
c_7	54	2.6
c_8	12	2.6

Intermediate map



ELECTRE TRI

Decision map



Obj.	Cat.
c_1	2
c_2	3
c_3	1
c_4	1
c_5	2
c_6	3
c_7	2
c_8	1

Choice of the GIS

- Lot of Open Source GIS (Grass, PostGIS, Quantum GIS, ...)
- See http ://opensourcegis.org/ for complete list

Choice of the GIS

- Lot of Open Source GIS (Grass, PostGIS, Quantum GIS, ...)
- See http ://opensourcegis.org/ for complete list

And the winner is :

- Linux and Windows compatible
- Written in C++ and Python
- Plugin mechanism included
- Using QT library
- Map algebra included

Quantum GIS - User interface

QT library

- Owned by Nokia
- LGPL license
- Available on a lot of platforms (Linux, Windows, ...)
- QT bindings for a lot of language (C++, python, java, ...)
- Lot of GUI possibilities
- QT Designer for user interface design

Quantum GIS - Generation of a decision map

Step 1 : Criteria map

- Quantum GIS includes lot of tools to construct different criteria map (fTools package includes map algebra)
- Vector layers only

Step 2 : Intermediate map

- *Union* tool included in Quantum GIS fTools package

Step 3 : ELECTRE TRI module

- Implemented as a plugin for Quantum GIS

Step 4 : Decision map

- Generated by the ELECTRE TRI module
- Use of Quantum GIS rendering capabilities

Quantum GIS - ELECTRE TRI module

Main components

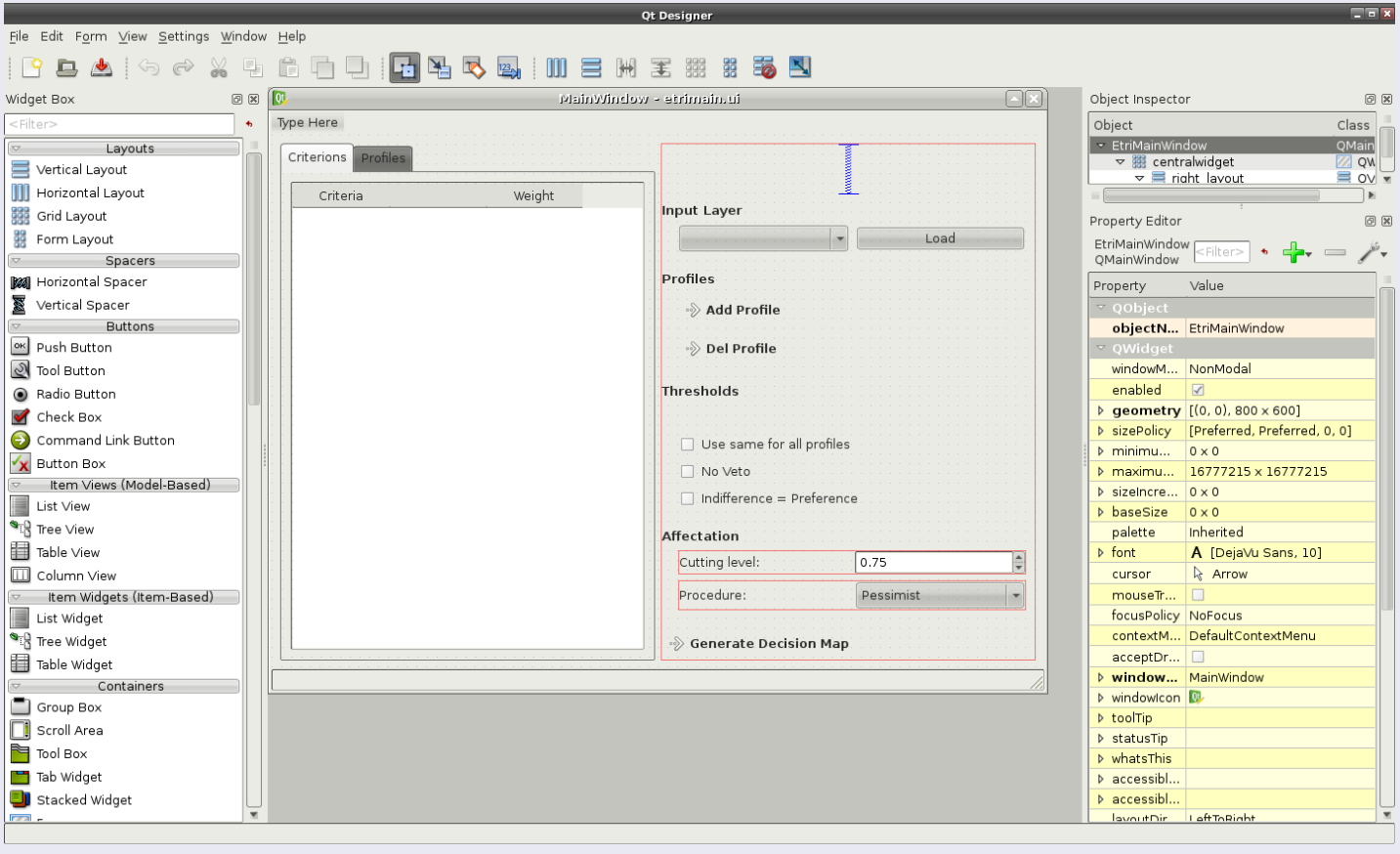
- ELECTRE TRI class
- User interface
- Decision map generator

Technical details

- Programming language : python
- User interface : PyQT
- Version Control System : git
- Project hosted on : github (http ://github.com/oso/qgis-etri)

Quantum GIS - ELECTRE TRI module

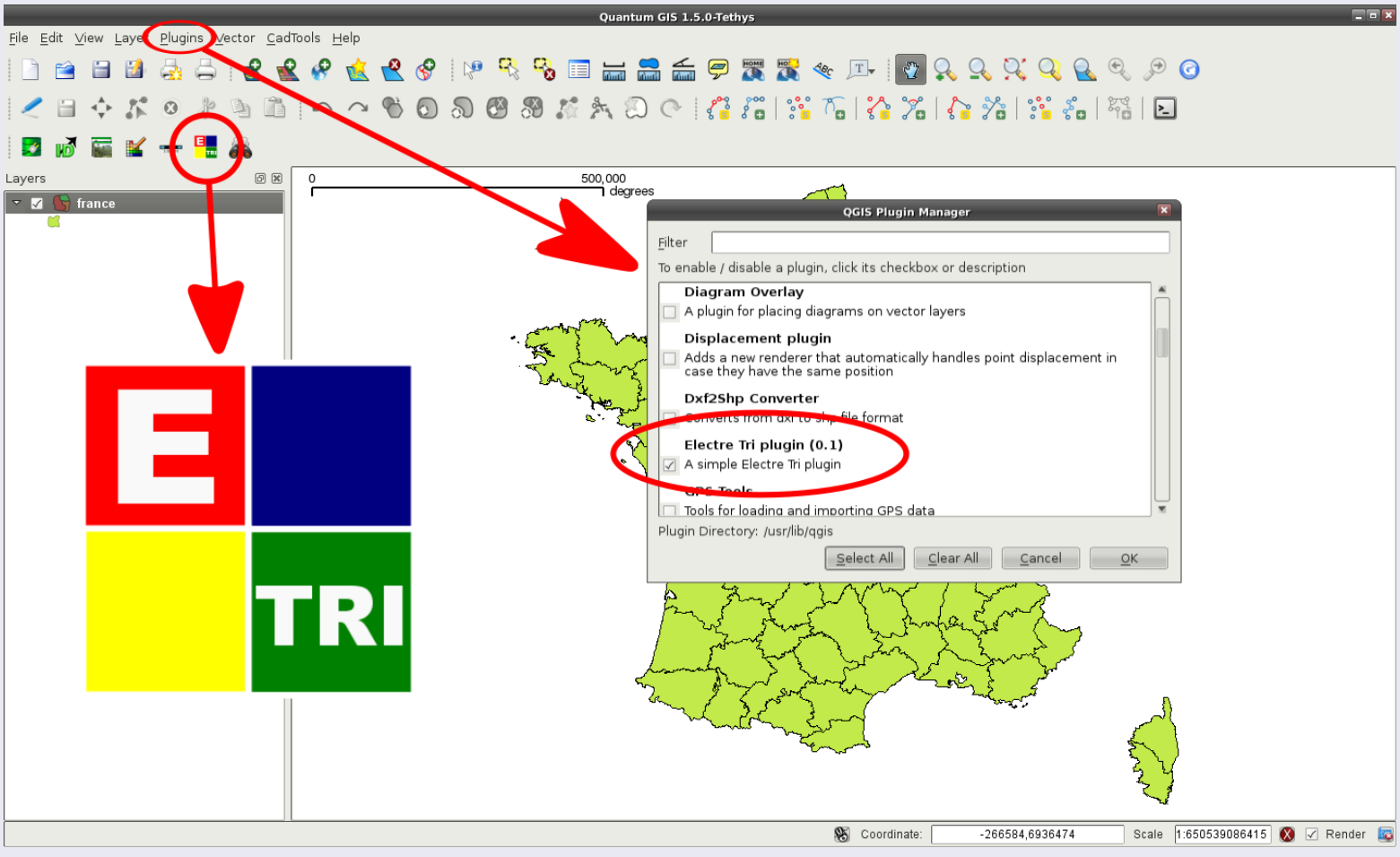
User interface conception

1. 

2. `pyuic4` to generate python code

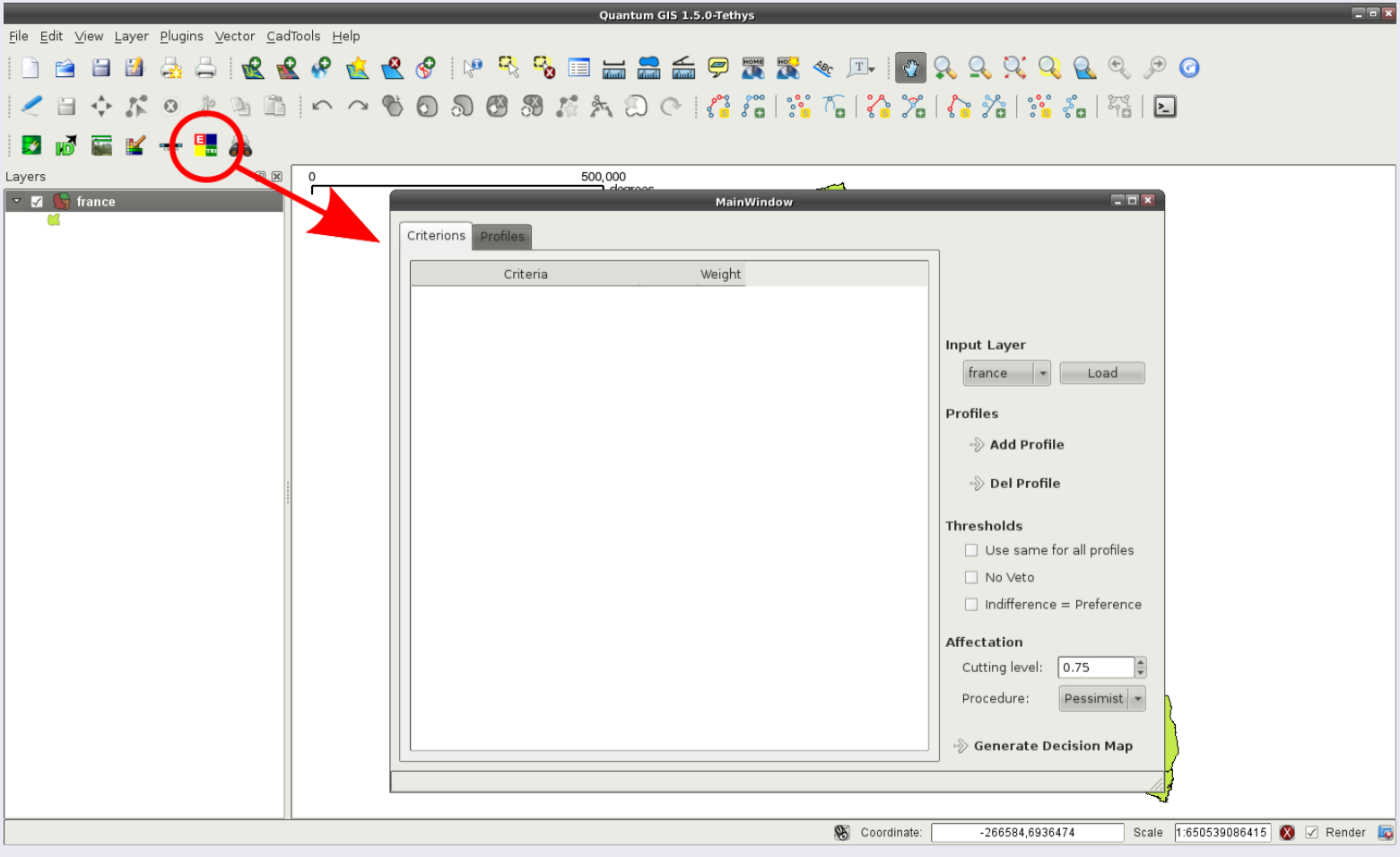
Quantum GIS - ELECTRE TRI module

Full coupling



Quantum GIS - ELECTRE TRI module

Now it's time for a demo...



Demonstration 1 - Burkina Faso

Goal

Evaluation of landscape degradation in the watershed of Loulouka (Metchebon 2010)

Actions

229 squares of 25ha

Criteria

- 11 criteria
- Ordinal scale :
  1. Inadequate
  2. Moderately adequate
  3. Adequate

Categories

1. Inadequate
2. Weakly adequate
3. Moderately adequate
4. Adequate

Demonstration 2 - Valley of Ticino

Goal

Choose the best location for the installation of a waste treatment plant in the valley of Ticino
(Maystre and al. 1994)

Actions

7 actions (points)

Criteria

- 5 criteria
- Quantatitave and qualitative scales

Categories

1. Bad
2. Good
3. Very good

Next steps

Inference module

- Conception of the UI for the inference module
- Integration with a solver and XMCDA web services

Improve User Interface

- Simplify some actions
- Better error handling

Add features

- Draw profiles
- ...

Thank you for your attention !