

# Integration of decision aid tools in a Geographical Information System

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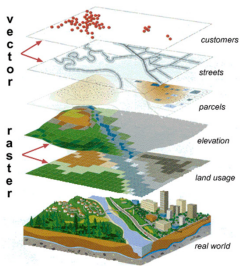
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- 1** Introduction
- 2** Methodology
- 3** Implementation
- 4** Inference
- 5** Demonstration
- 6** Conclusion

# 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

# GIS and MCDA

## Limitations of GIS-MCDA works according to [Chakhar, 2006] :

- ▶ Weak coupling
- ▶ One MCDA method integrated (Single criterion synthesis)
- ▶ Choice of the MCDA method
- ▶ User's knowledge of GIS and MCDA

# GIS and MCDA

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## We add an extra one :

A good number of GIS-MCDA tools were abandoned or never surpassed the stage of prototype. Moreover it has been done in commercial GIS.

# Objectives of our GIS-MCDA integration

## First objectives

- ▶ ELECTRE TRI implementation
- ▶ Full integration
- ▶ User friendly interface
- ▶ Open Source GIS (and implementation)

# Objectives of our GIS-MCDA integration

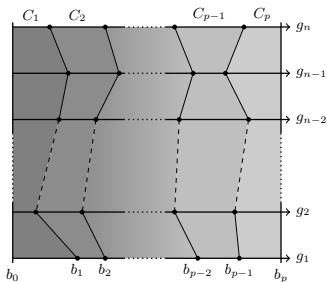
## First objectives

- ▶ ELECTRE TRI implementation
- ▶ Full integration
- ▶ User friendly interface
- ▶ Open Source GIS (and implementation)

## Second objectives

- ▶ Learning of parameters
- ▶ Implementation of a XMCDA webservice
- ▶ Experimentations
- ▶ Coupling with the ELECTRE TRI plugin

# ELECTRE TRI



## Parameters

- ▶ weights
- ▶ profiles
- ▶ credibility threshold
- ▶ ...

## Approach

- ▶ Classical
- ▶ Bouyssou-Marchant

## Major interests

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



# Application : Densification of Quebec city

## Subject

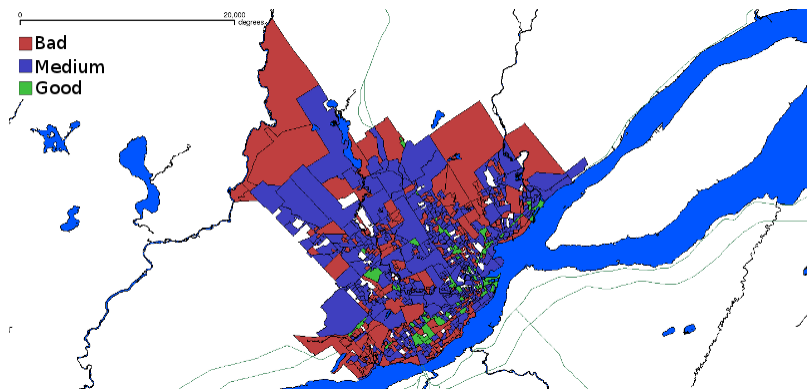
Quebec city wants to create a program to densify its population in the centrum and around the small crown. The program consists to build rental properties at low prices for young families in empty areas.

## Objectives

- ▶ Densify central sectors where there are more public transports
- ▶ Sustain a good social diversity by choosing in priority the sectors where young people and immigrants are not well represented
- ▶ Favor sectors with a lot of small shops

# Application : Densification of Quebec city

## Decision map



# Application : Densification of Quebec city

## Definition of the problem

### Actions

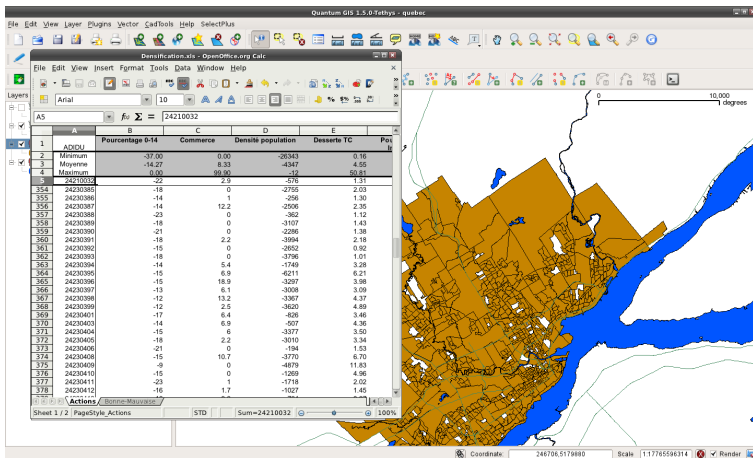
786 districts (polygons)

### Criteria

- ▶ Density of 0-14 years old [%] (min)
- ▶ Density of shops [shops/ha] (max)
- ▶ Density of people [residents/ha] (min)
- ▶ Level of public transports (average) [bus/hour] (max)
- ▶ Ratio of immigrants [%] (min)

# Application : Densification of Quebec city

## Performance table



# Strategy of integration

## Reference

- ▶ [Chakhar, 2006]

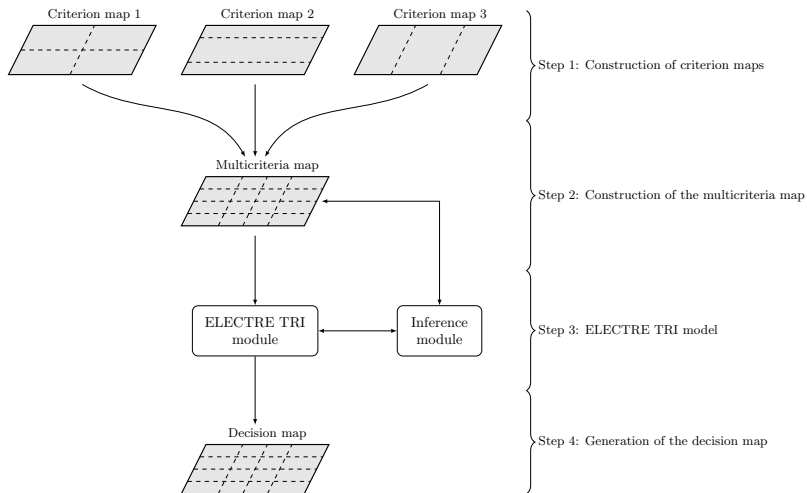
## Coupling strategy

- ▶ [Malczewski, 2006] reports only 10 % of works using a strategy of full integration of the MCDA method in the GIS
- ▶ Full integration

## Actions and criteria

- ▶ Vector layer
- ▶ actions = points, lines, polygons
- ▶ criteria = attributes

# Strategy to build the decision map



# Choice of the GIS

## Requirements

- ▶ Open Source GIS and implementation
- ▶ User friendly interface
- ▶ Support of vector layer
- ▶ With map algebra tools

# Choice of the GIS

## Requirements

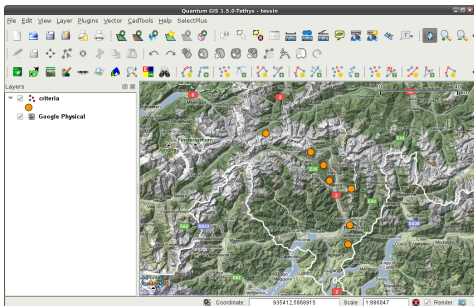
- ▶ Open Source GIS and implementation
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## Lot of open source GIS

- ▶ GRASS, PostGIS, Quantum GIS
- ▶ <http://opensourcegis.org/>



# Quantum GIS

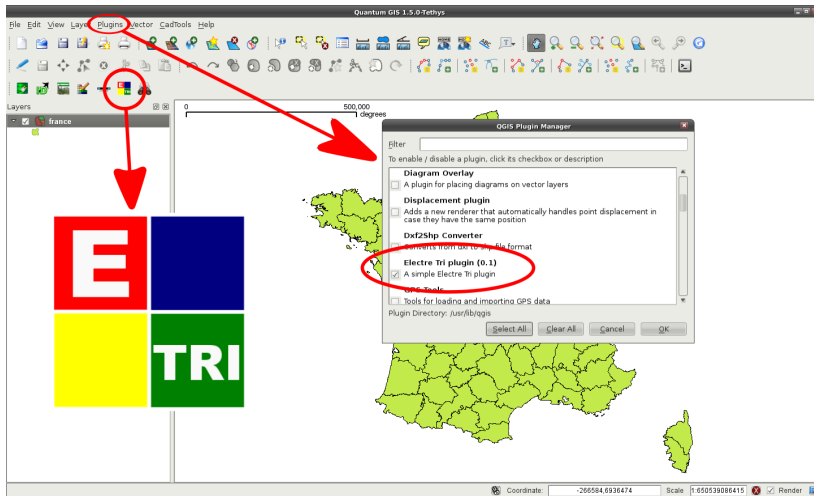


## Characteristics

- ▶ Great portability (Linux, Windows, Mac OS)
- ▶ Plugin mechanism
- ▶ Lot of functionalities (GRASS, map algebra, ...)
- ▶ User-friendly interface

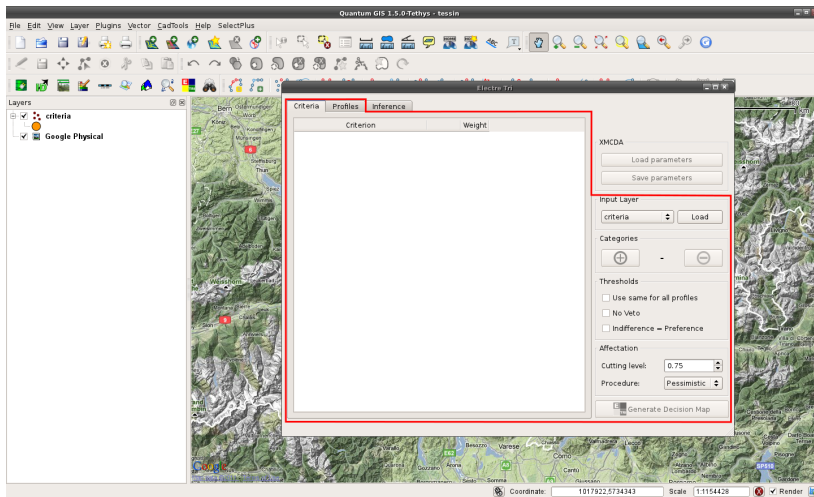
# ELECTRE TRI plugin

## Full integration



# ELECTRE TRI plugin

## User interface



# ELECTRE TRI plugin

## User interface

The screenshot displays the 'Electre Tri' application window with three tabs: 'Criteria', 'Profiles', and 'Inference'. The 'Criteria' tab is active, showing a table of criteria and their weights.

Criterion	Weight
<input checked="" type="checkbox"/> PRICE	Min 25.00
<input checked="" type="checkbox"/> TRANSPORT	Min 45.00
<input checked="" type="checkbox"/> ENVIRONMEN	Max 10.00
<input checked="" type="checkbox"/> RESIDENTS	Max 12.00
<input checked="" type="checkbox"/> COMPETITIO	Max 8.00
<input type="checkbox"/> Name	Max 10.00

On the right side of the interface, there are several control panels:

- XMCD A:** Contains 'Load parameters' and 'Save parameters' buttons.
- Input Layer:** A dropdown menu set to 'criteria' and a 'Load' button.
- Categories:** A green '+' button, the number '3', and a red '-' button.
- Thresholds:** Three checkboxes: 'Use same for all profiles' (unchecked), 'No Veto' (unchecked), and 'Indifference = Preference' (unchecked).
- Affectionation:** A 'Cutting level' dropdown set to '0.75' and a 'Procedure' dropdown set to 'Pessimistic'.
- Generate Decision Map:** A button with a small icon and the text 'Generate Decision Map'.

# ELECTRE TRI plugin

## User interface

Electre Tri

Criteria Profiles Inference

	PRICE	TRANSPORT	ENVIRONMEN	RESIDENTS	COMPETTIO
1	100.0	1000.0	4.0	4.0	15.0
2	50.0	500.0	7.0	7.0	20.0

Indifference Preference Veto

	PRICE	TRANSPORT	ENVIRONMEN	RESIDENTS	COMPETTIO
1	15.0	80.0	1.0	0.5	
2	15.0	80.0	1.0	0.5	

XMCD A

Load parameters

Save parameters

Input Layer

criteria Load

Categories

+ 3 -

Thresholds

Use same for all profiles

No Veto

Indifference = Preference

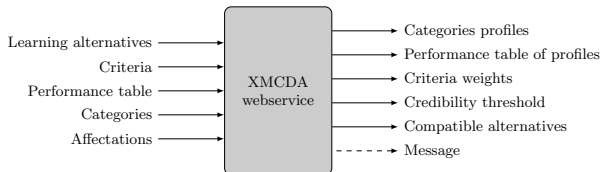
Affectation

Cutting level: 0.75

Procedure: Pessimistic

Generate Decision Map

# XMCDa webservice



## Characteristics

- ▶ Based on [Leroy, 2010]
- ▶ Learning of ELECTRE TRI Bouyssou-Marchant parameters
- ▶ Accept non-admissible set of learning alternatives
- ▶ Maximize number of compatible alternatives
- ▶ MIP problem
- ▶ Use GLPK

# ELECTRE TRI BM inference experimentations

## First conclusions

- ▶ Lot of learning alternatives needed to get good results
- ▶ Difficult to get good set of params when learning set not completely compatible with ELECTRE TRI model
- ▶ Computing time becomes huge when number of learning alternatives increases

# ELECTRE TRI BM inference experimentations

## First conclusions

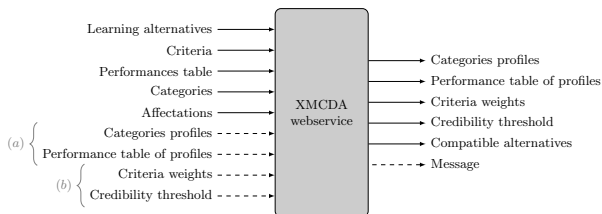
- ▶ Lot of learning alternatives needed to get good results
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## New experimentations

- ▶ Two step inference
- ▶ Partial inference
- ▶ Improve objective of the inference program



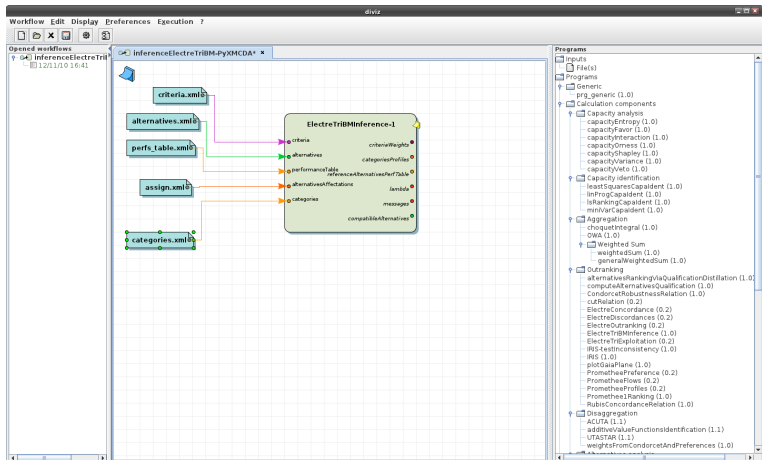
# ELECTRE TRI BM inference webservice update



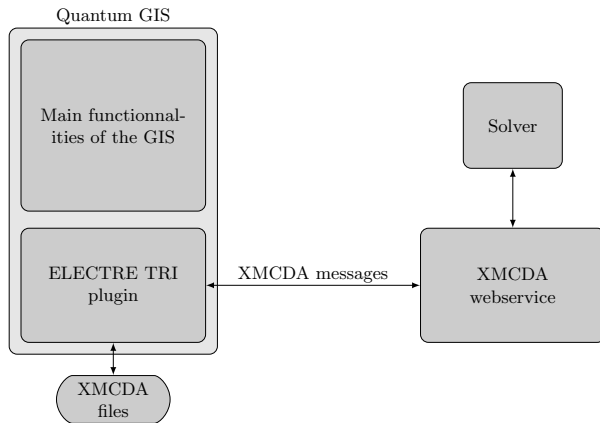
## Characteristics

- ▶ Two entries added to do partial inference of the weights and lambda threshold
- ▶ Two entries added to do partial inference of the profiles

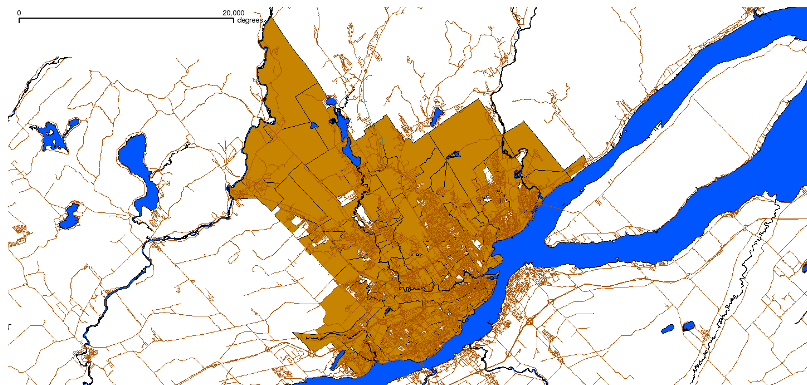
# Webservice available in diviz



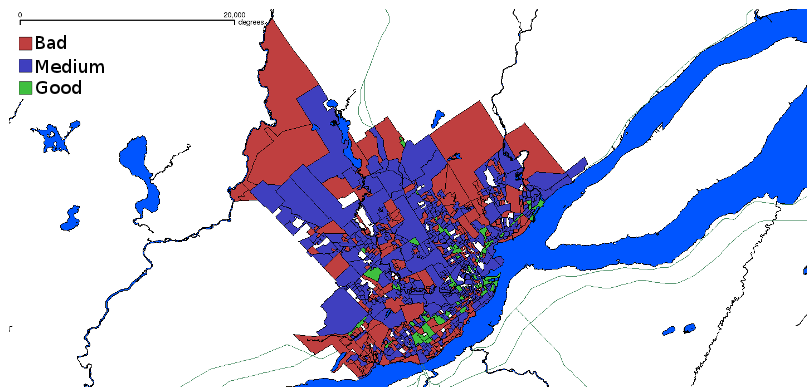
# Coupling of XMCDA webservice with Quantum GIS ELECTRE TRI plugin



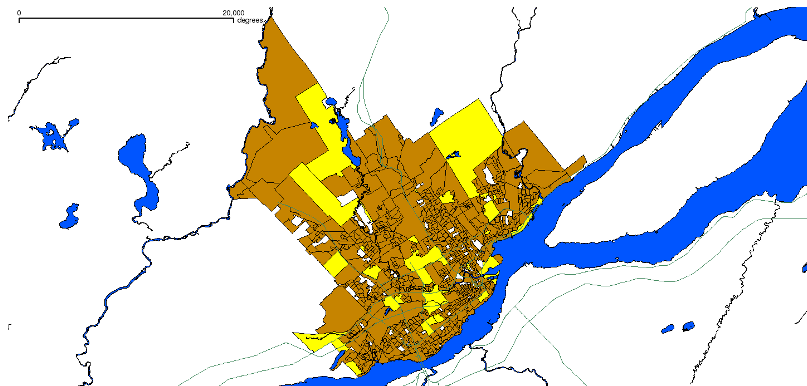
# It's time for the demo...



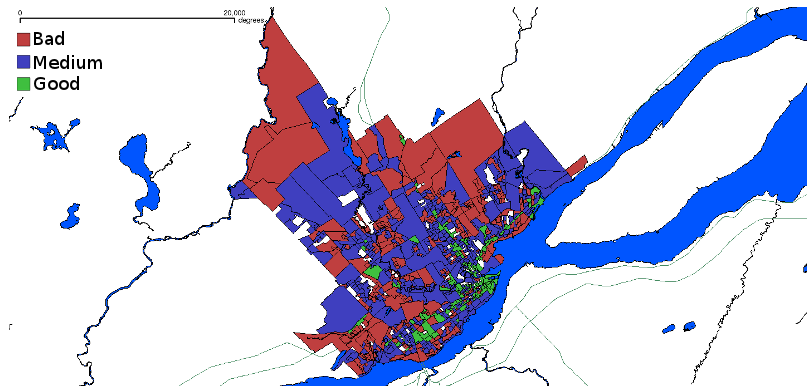
# Original model



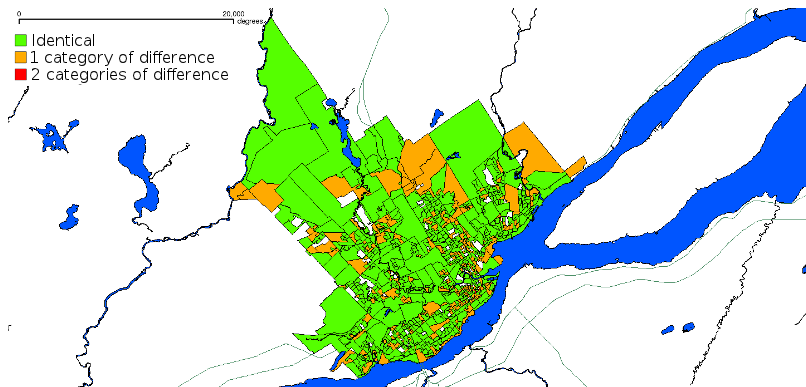
# Actions of reference



# Global inference



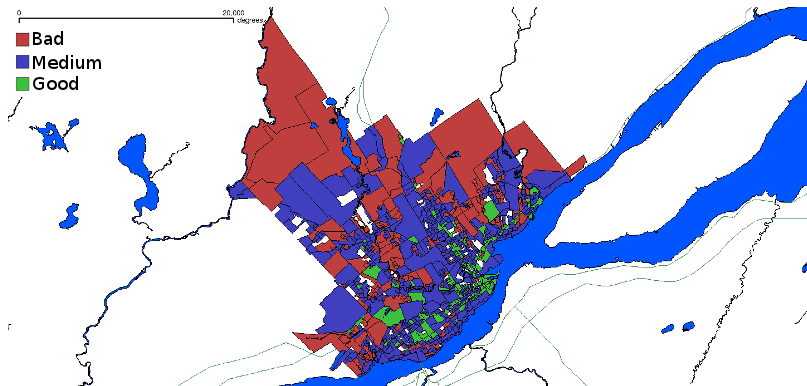
# Global inference (difference)



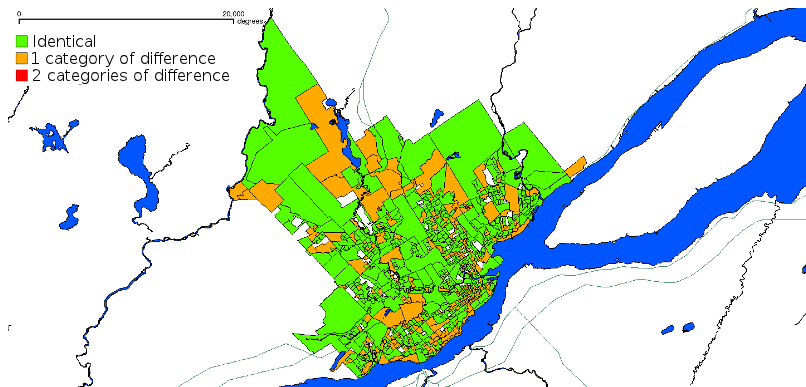
± 29% of invalid affectations



# Profiles inference

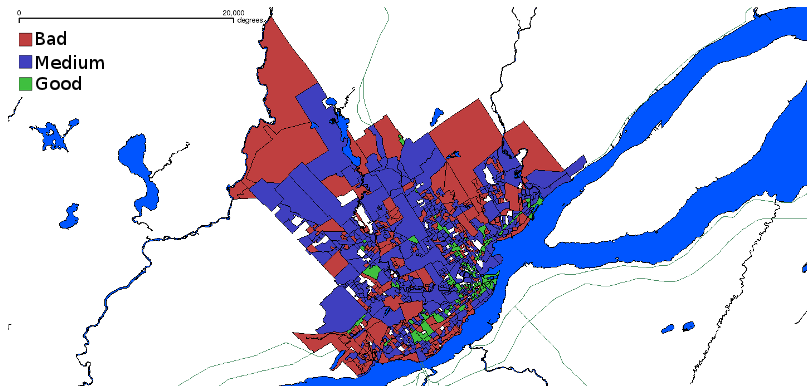


# Profiles inference (difference)

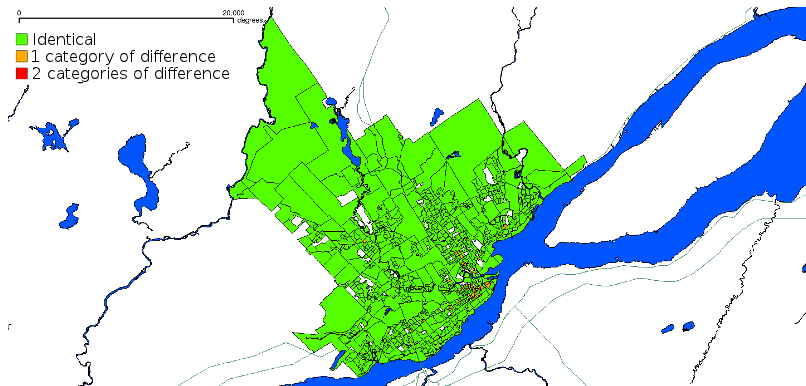


$\pm 33\%$  of invalid affectations

# Weights and lambda inference



# Weights and lambda inference (difference)



± 6% of invalid affectations

# Conclusion

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- ▶ Full open source solution running on several OS
- ▶ Limitations of GIS-MCDA overcome by the full integration
- ▶ Several spatial decision problems treated

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## Ideas for improvements

- ▶ Improve userfriendliness of the plugin
- ▶ Improve the inference procedure
- ▶ Better take into account geographical aspects
- ▶ Algorithm to choose an optimal learning set

Thank you for your  
attention !

# References



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