

WWW-YES 2012 FRANCE

12<sup>th</sup> World wide Workshop for Young Environmental  
Scientists

# A spatial and temporal analysis for long term renewal of water pipes



Urban waters: Resource or Risk?  
WWW-YES-2012  
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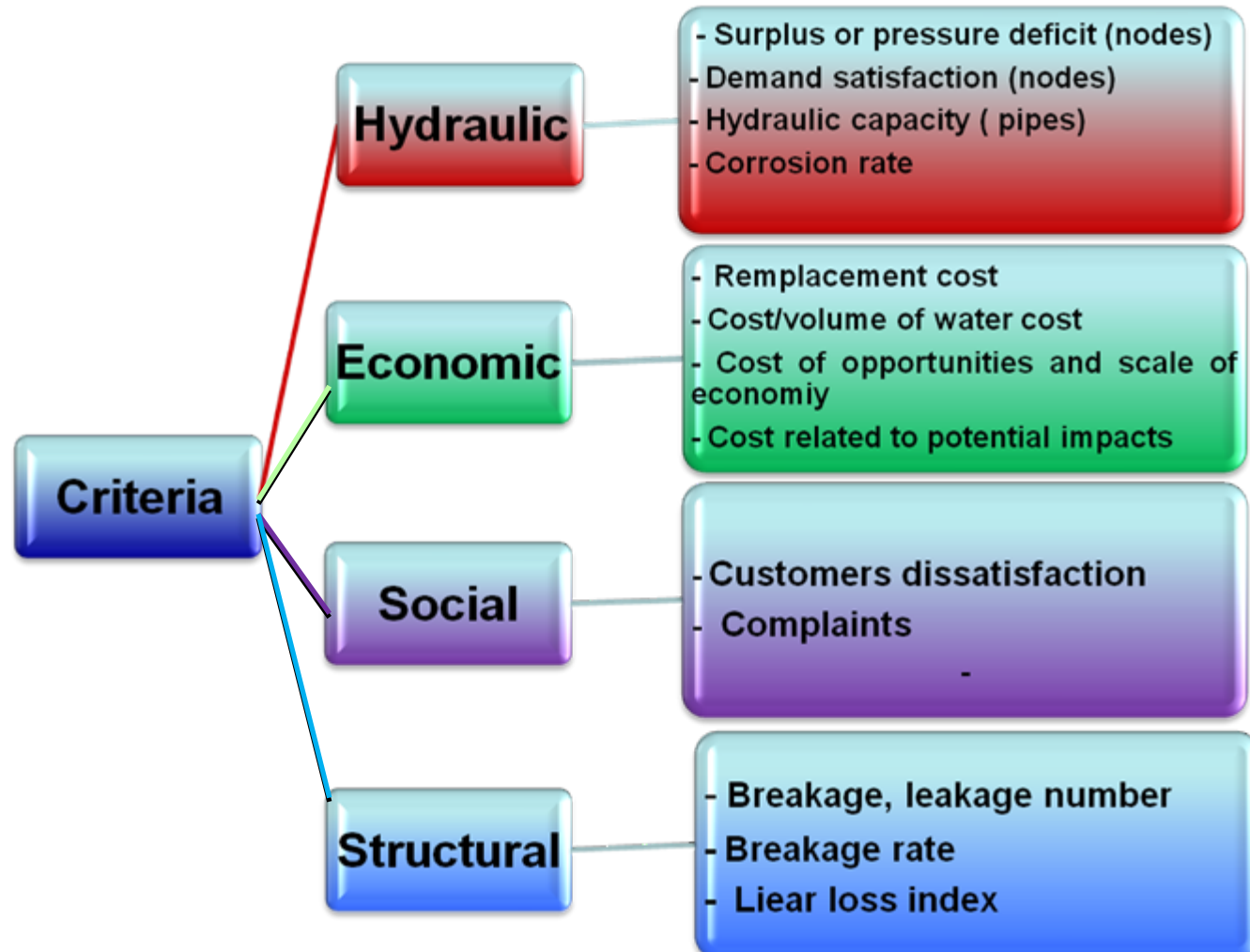
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# PRIORITIZATION CRITERIA

(Utilnets, Caree-W  
Le Gauffre and  
Haidar, (2008),  
Kanew, Riva,  
Sirocco, Prams,  
Water Gems, Nafi  
and Werey, (2009),  
Dridi et al, (2006),  
Halfawy et al, (2008)  
and Giustolisi and  
Berardi, (2009))



# WHAT'S CLUSTERING?

- **Process of creating data collection :**
  - **Similar within the same group**
  - **Dissimilar when they belong to different groups.**
- **Clustering is the unsupervised classification: without previously predefined classes.**

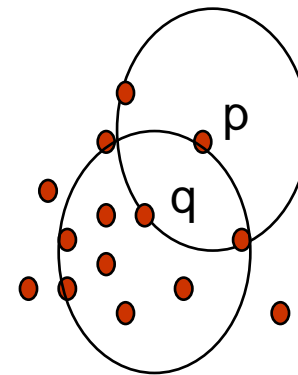
## What's a good clustering?

- **Ensures a high similarity «within-group»**
- **Allows dissimilarity "inter-group."**

# CLUSTERING ALGORITHM

1. Identifies groups of incidents that are spatially close
2. It is a hierarchical clustering routine that clusters points together on the basis of a criterion called a threshold distance
  1. determined by random distance algorithm or used defined
  2. Minimum number of events may also be defined
3. Clustering is repeated until either all points are grouped or the clustering routine fails

- 1)  $p \in VEps(q)$
- 2)  $|VEps(q)| \geq MinPts$



MinPts = 5

Eps = 1

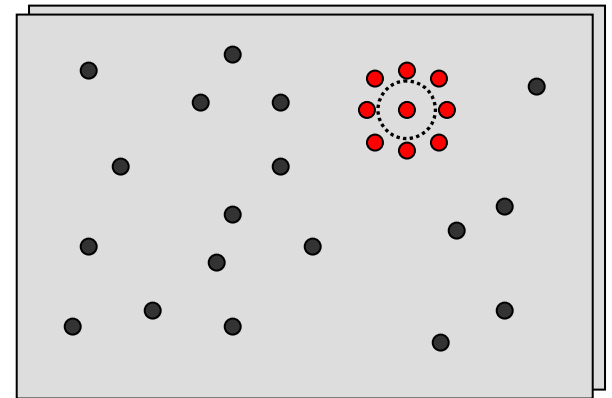
# CLUSTERING ALGORITHM

## Detection of break points approaches

- Select  $p$  (basic break point)
- Detect all break points from  $p$  respectively  $Eps$   $\epsilon$
- If  $p$  is a center, a cluster is formed.
- If  $p$  is a limit, there is no accessible break point from  $p$ , move to another point.
- Repeat the same processus until all all break points are grouped (clustered).

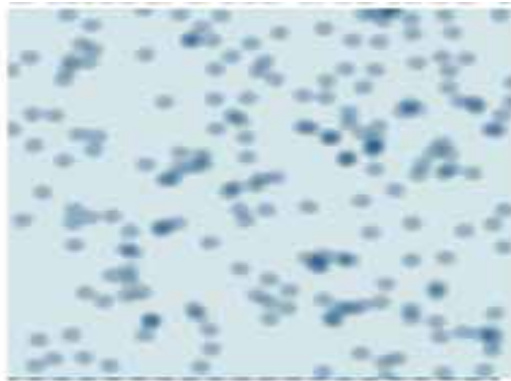
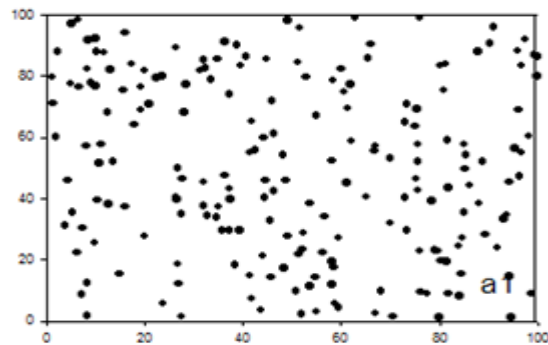
Detection failure when there is no a significant density in a certain neighborhood.

data points  
local  
interesting  
points in clusters.

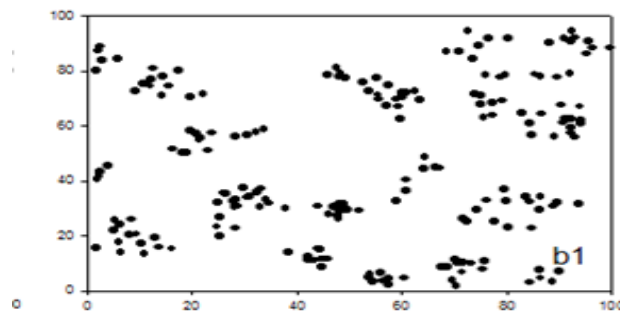


# HOW BREAKS ARE – THEY DISTRIBUTED IN A WDN ?

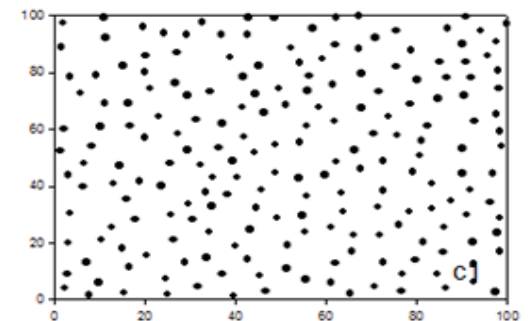
Random



Cluster



Regular



# NEAREST NEIGHBOR INDEX (NNI)

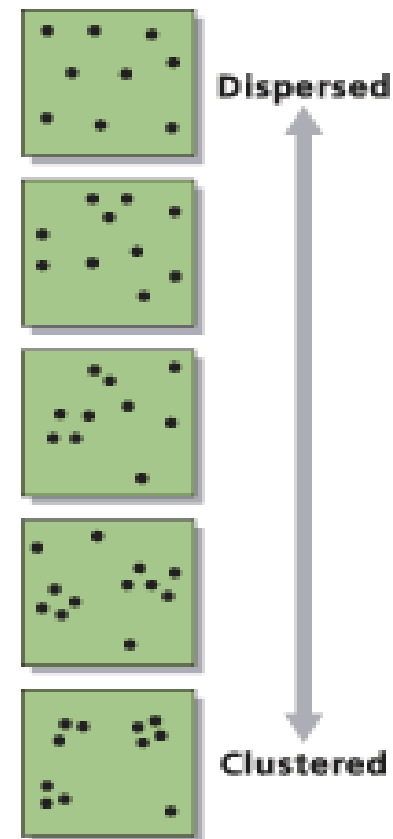
$$NNI = \frac{\overline{NND}}{\overline{NND}_R} \quad \overline{NND} = \frac{\sum_{i=1}^n NND}{n}$$

$$\overline{NND}_R = \frac{1}{2\sqrt{Density}} \quad Density = \frac{n}{A}$$

- $n$  is the **number of failures**.
- $A$  is the **size** of the analyzed area,
- $NNI$  the ratio of the **observed distance** to the expected distance (Nearest neighbour index)
- $NND$  is the **distance** between each failure location and its nearest neighbour.

$\overline{NND}$  : the observed **mean distance** between nearest neighbours

$\overline{NND}_R$  : the expected value of the nearest neighbour distance in a **random pattern**.

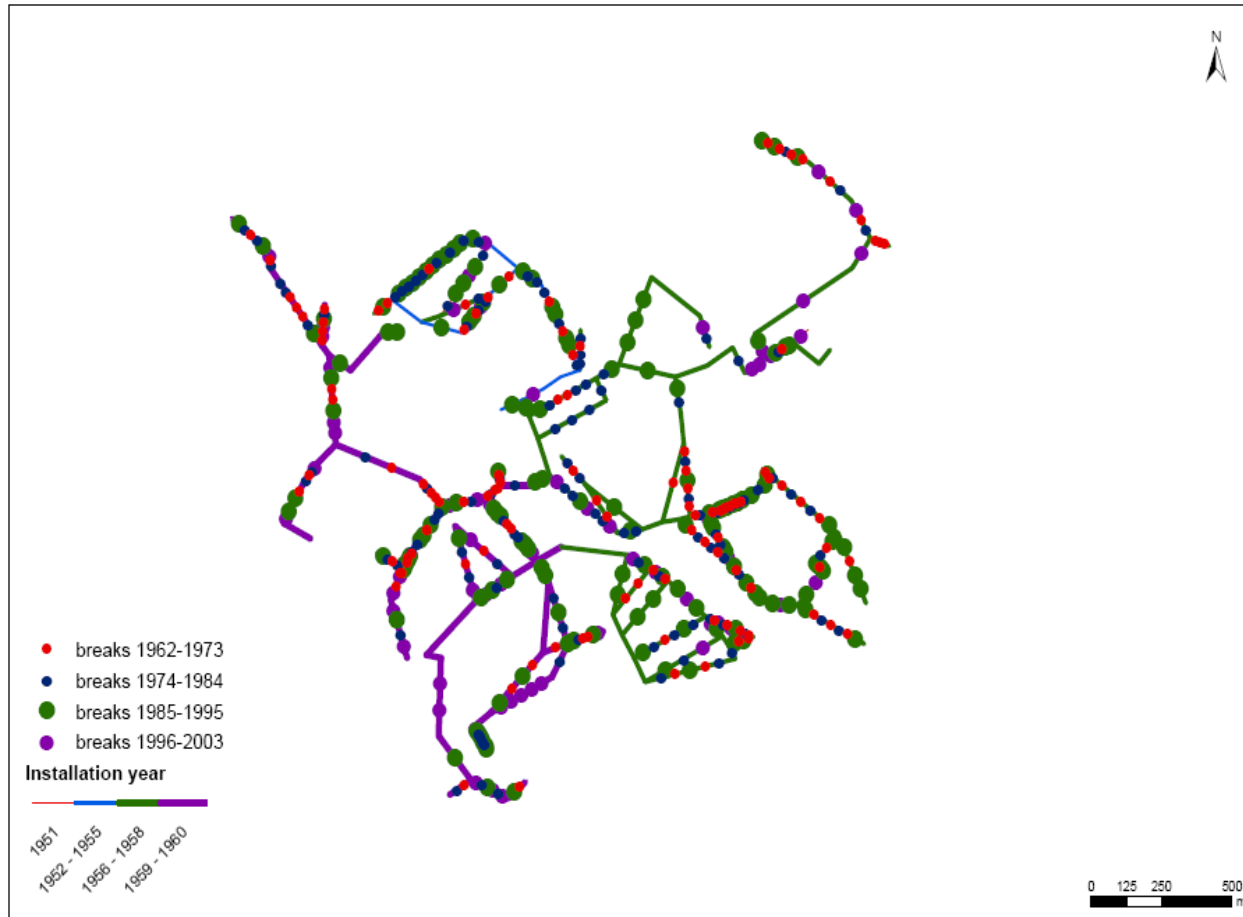


# NEAREST NEIGHBOR INDEX (NNI)

Order	Mean Nearest Neighbor Distance (m)	Expected Nearest Neighbor Distance (m)	Nearest Neighbor Index
1	38.7798	159.9100	0.24251

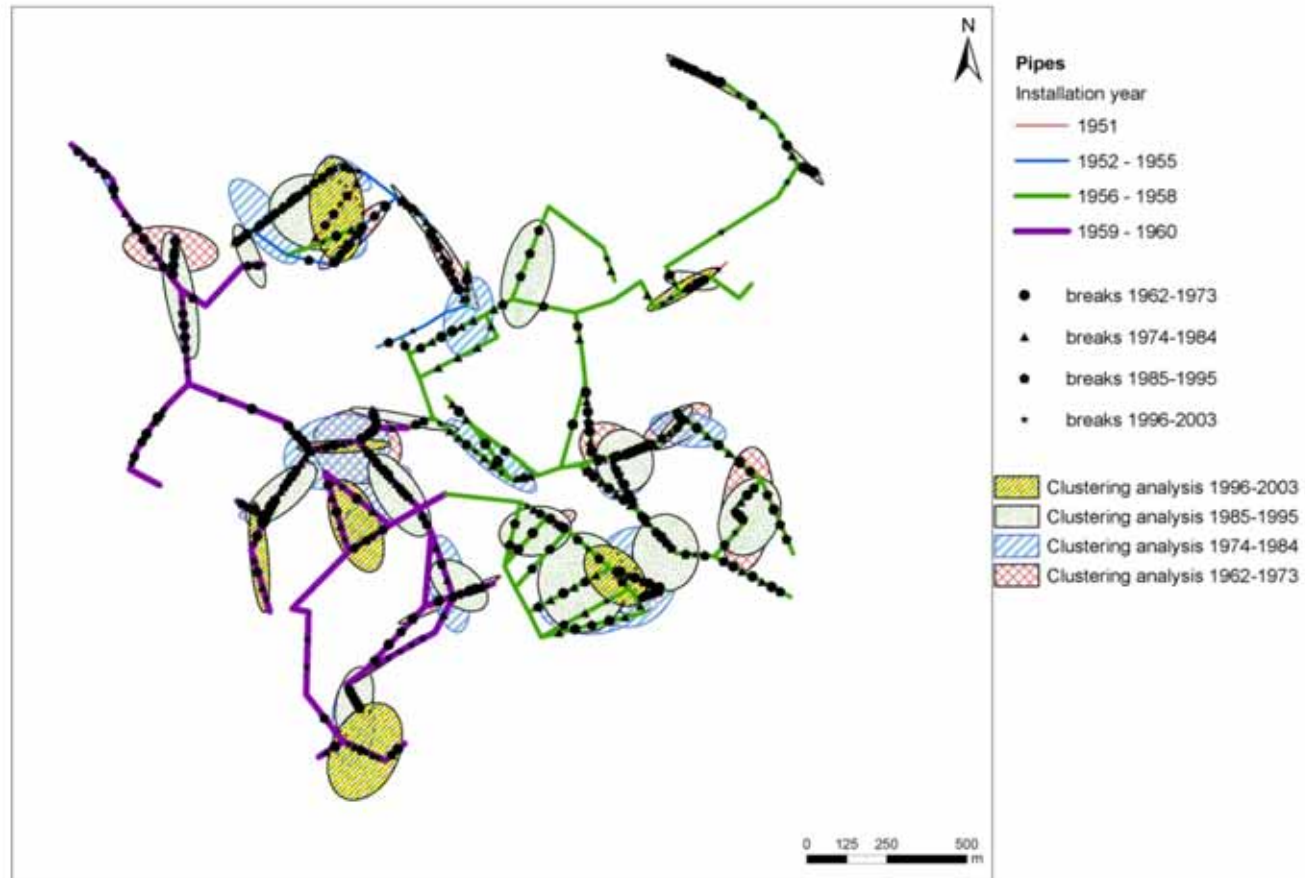


# SPATIAL ANALYSIS



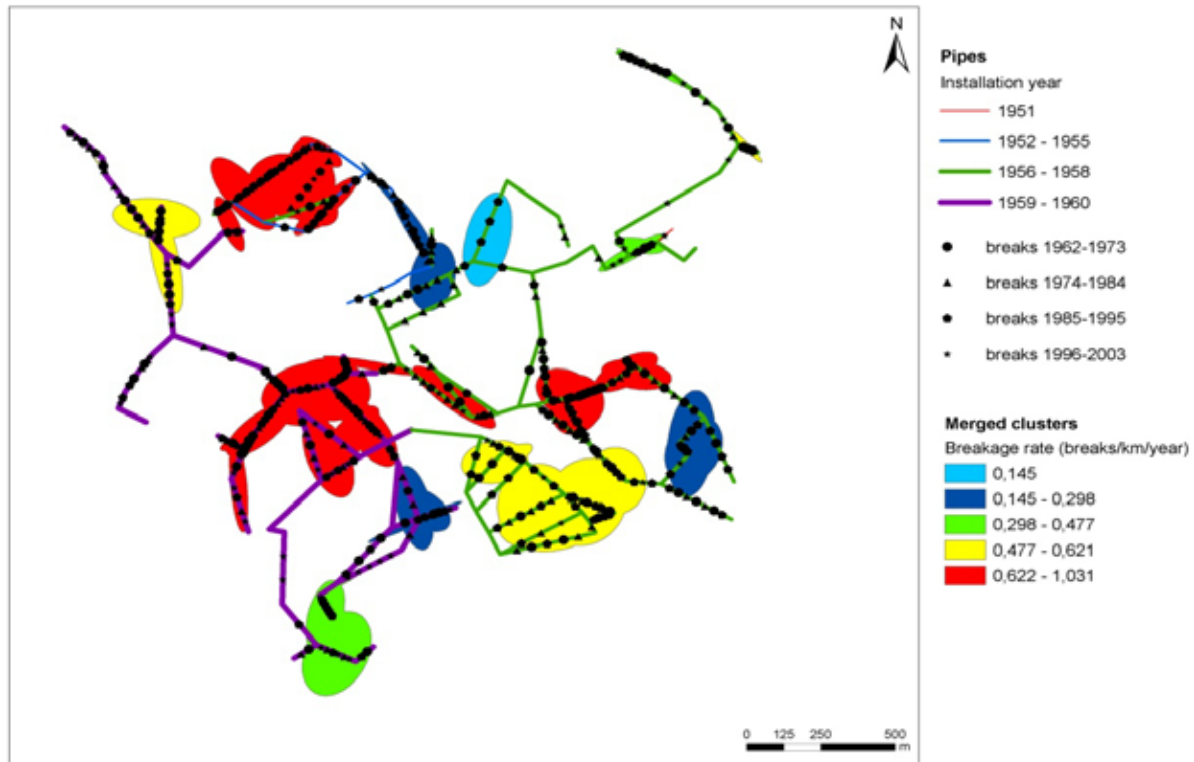
**Fig.1. Case study**

# HOTSPOT ANALYSIS

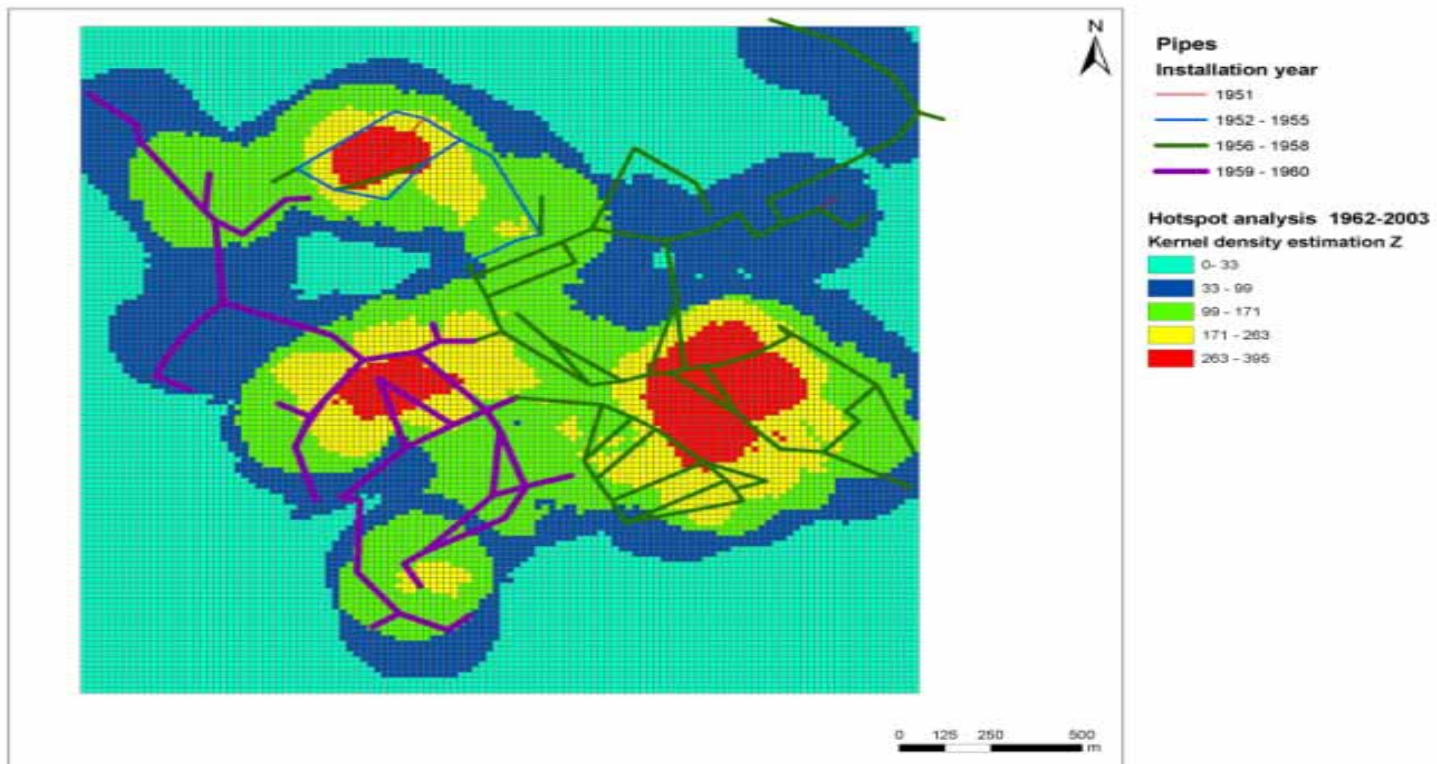


**Fig.2. Analysis**

# HOTSPOT ANALYSIS

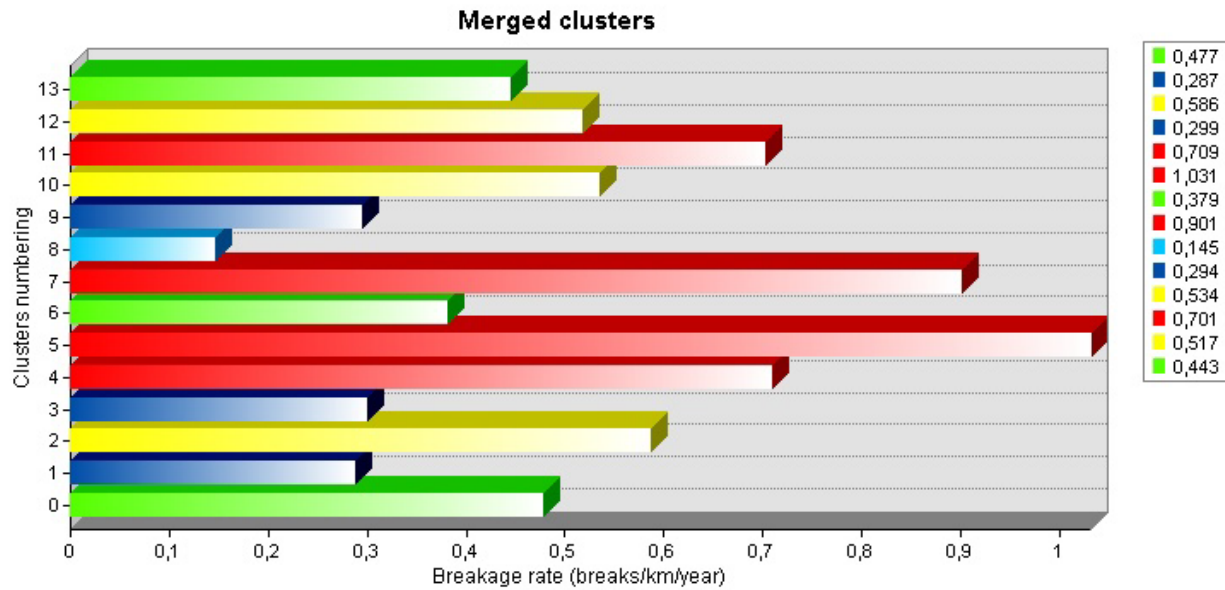


**Fig.3. Merged clusters**

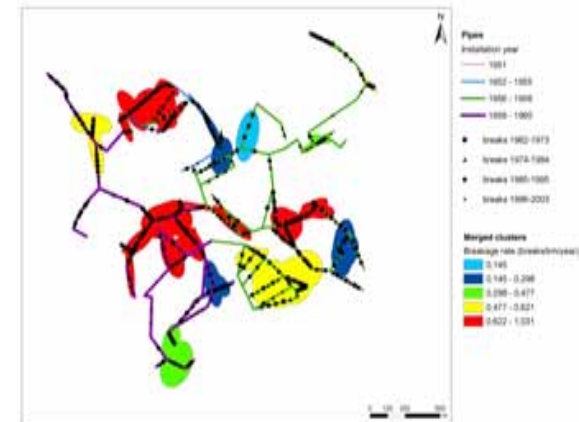


**Fig.5. Hotspot analysis: Kernel density estimation.**

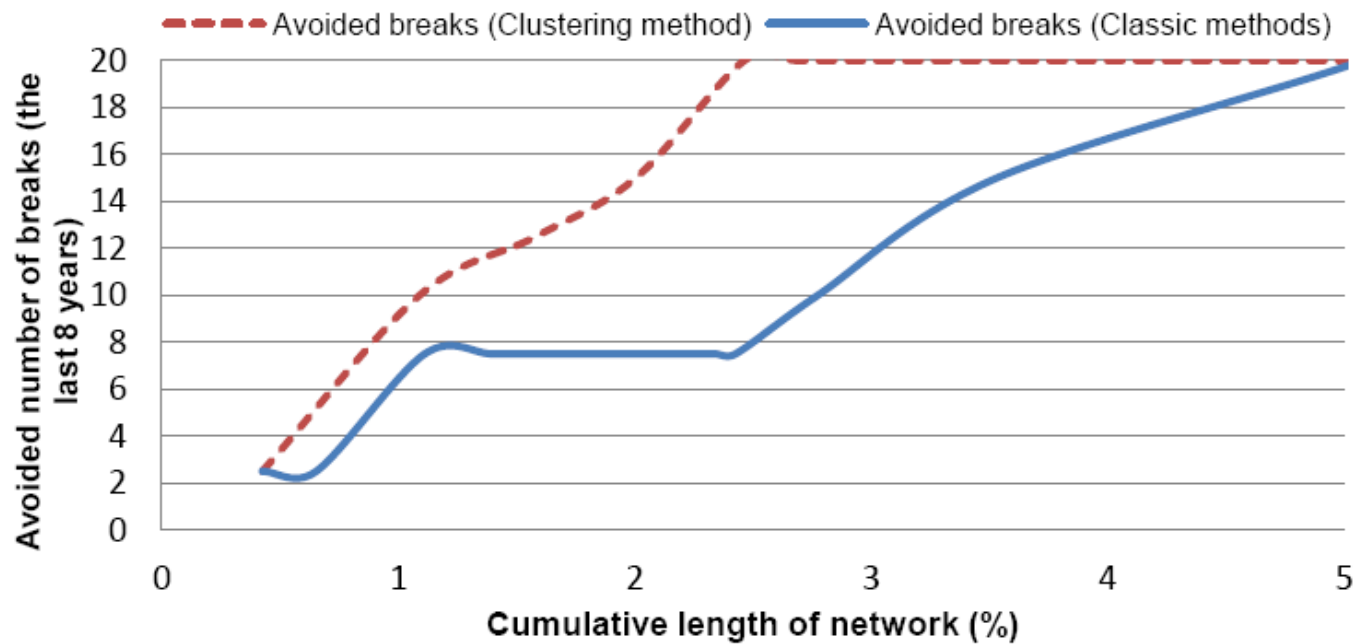
# HOTSPOT ANALYSIS



**Fig.5. Breakage rate/cluster**

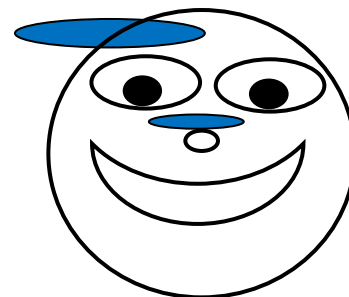


# RESULTS

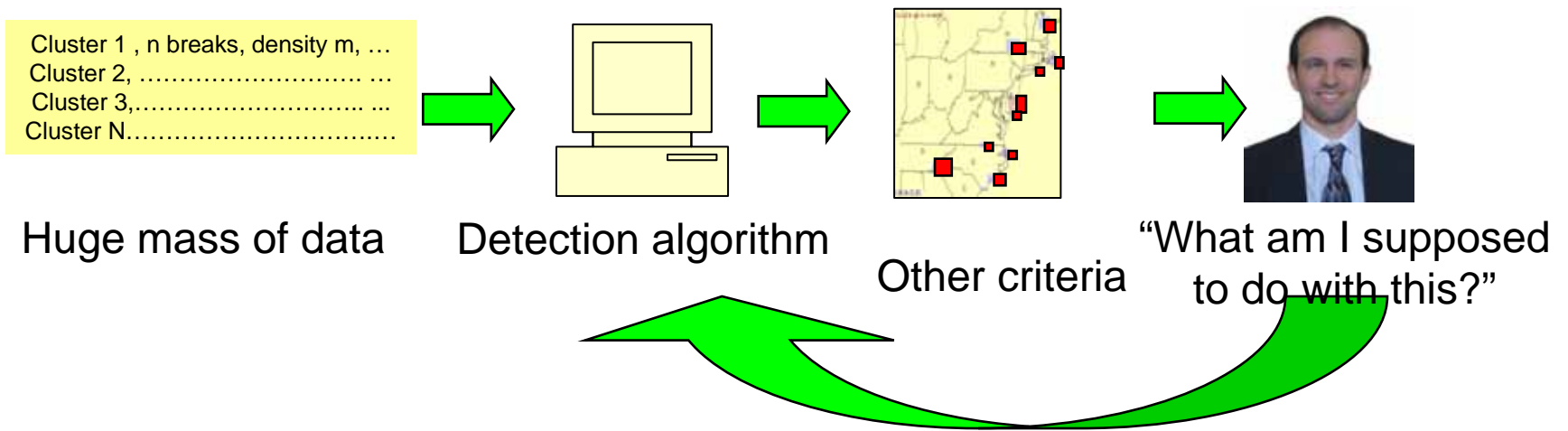


**Fig.5. Avoided breaks**

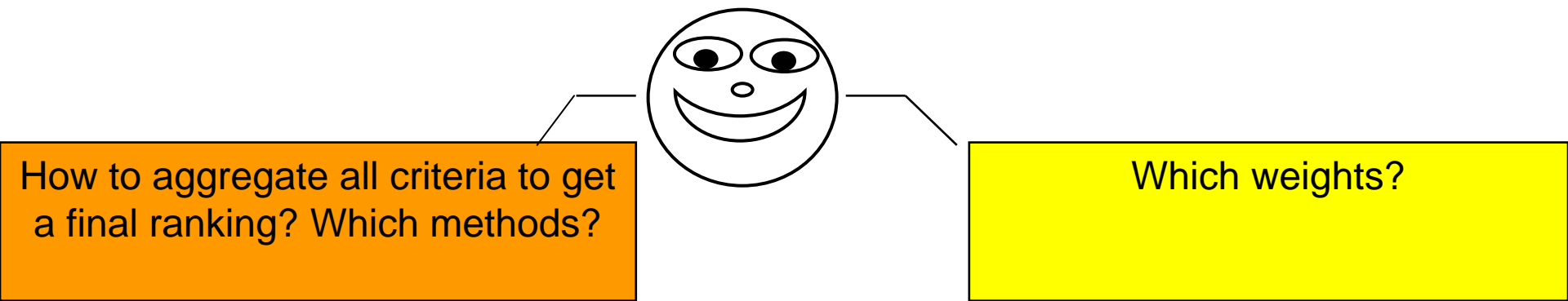
THANKS FOR YOUR  
ATTENTION



Does the clustering is a pertinent criterion for water pipe prioritization for replacement? Yes!!!



Multi-criteria decision making for prioritizing water pipes





Criteria, <i>j</i>	unit	Assessment function, $g_j()$
<i>Breakage rate</i>	#/km/year	Number of pipe breaks (failures) during an observation window $[t_a, t_b]$ divided by the pipe length and by the duration of the observation window
<i>Demand</i>	m <sup>3</sup>	The peak period demand identified along the pipe (or at both sides of pipe, if we assume that demand is gathered in nodes)
<i>Hydraulic capacity</i>	/	Expresses the physical condition of the pipe section. It is described by the Hazen-Williams coefficient
<i>Residual lifetime</i>	Year (s)	Evaluate the end of service life of a pipe according to a theoretical lifetime which can be either the average and technical lifetime duration or the accounting lifetime used for the calculation of the depreciation. The residual lifetime is expressed as the proportion of the remaining service lifetime of a pipe compared to a theoretical service life. We recommend differentiating between the theoretical lifetime based on the nature of material and pipe diameter.
<i>Belonging to a loop or branch</i>	/	Evaluate the pipe role on the water supply and the impact of a random event on the service reliability. Indeed, if a pipe is in a loop, its failure will affect less the water supply than another in a branch or the network extremities.
<i>Material</i>	/	According to the decision makers, the material with which a pipe is made, constitutes a renewal criterion. The analysis of the failure history allows determining the most vulnerable materials and therefore offers a first ranking according to the type of material.
<i>Clustering</i>	#/cluster/year	The belonging of a pipe to a cluster is used as a renewal criterion. In addition, the ranking of a pipe candidate for renewal will be based on the breakage rate of the cluster to which it belongs
<i>Diameter</i>	mm	The pipe diameter may be a criterion of renewal; however it's implicitly combined with the breakage rate. Usually large diameters fail less than smaller ones.