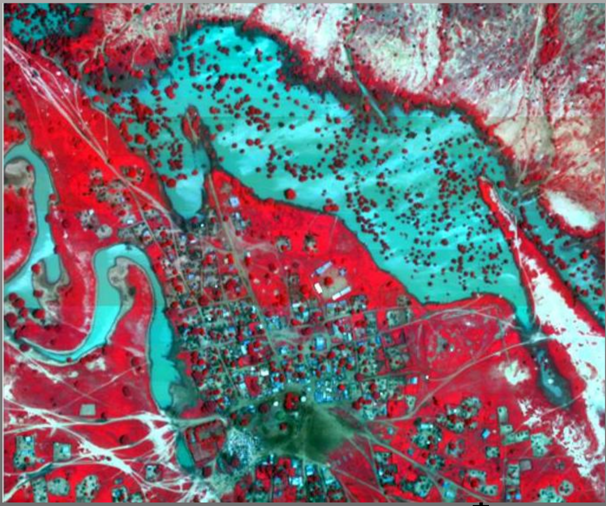
Landscape characterization of Rift Valley Fever risk areas using very high spatial resolution imagery : case study in the Ferlo area, Senegal.

V.Soti[1,2,3], V.Chevalier[1], J.Maura[1], D.Sow[5], A. Begue[2], C.Lelong[2], R. Lancelot[4], A. Tran[1,2]

1: Cirad, AGIRs ;2: Cirad, UMR TETIS; 3: Cirad, UPR SCA ; 4: Cirad, UMR15; 5: ISRA,Dakar, Sénégal



Outline

I. Study context
- 1.1 Study area
- 1.2 The Rift Valley Fever
- 1.3 Objectives and approach

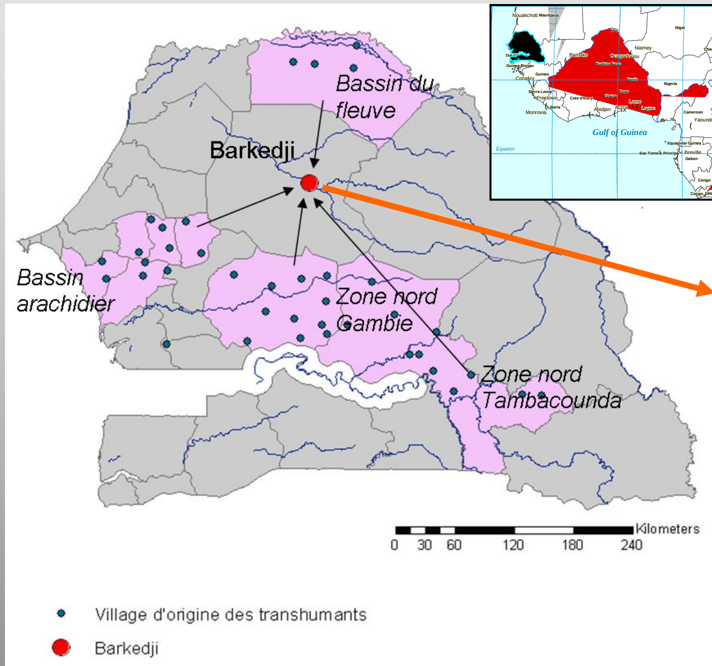
II. Image processing
- 2.1 Water detection
- 2.2 Vegetation maps

III. Landscape analysis
- 3.1 Definition of landscape indices
- 3.2 Extraction of landscape indices
- 3.2 Statistical analysis

IV. Conclusions and perspectives

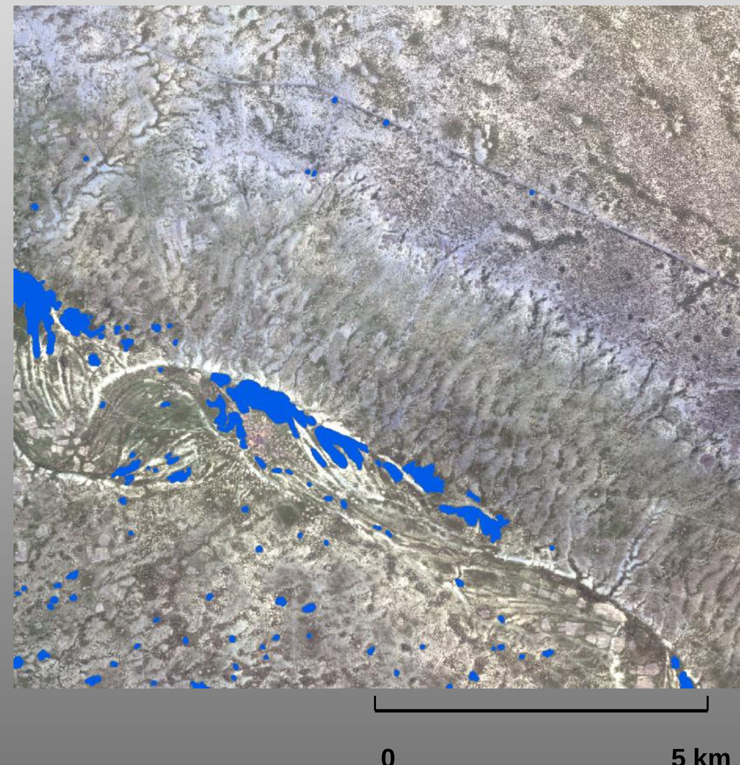
Study area

➢ Agropastoral zone



➢ Sahelian climate :

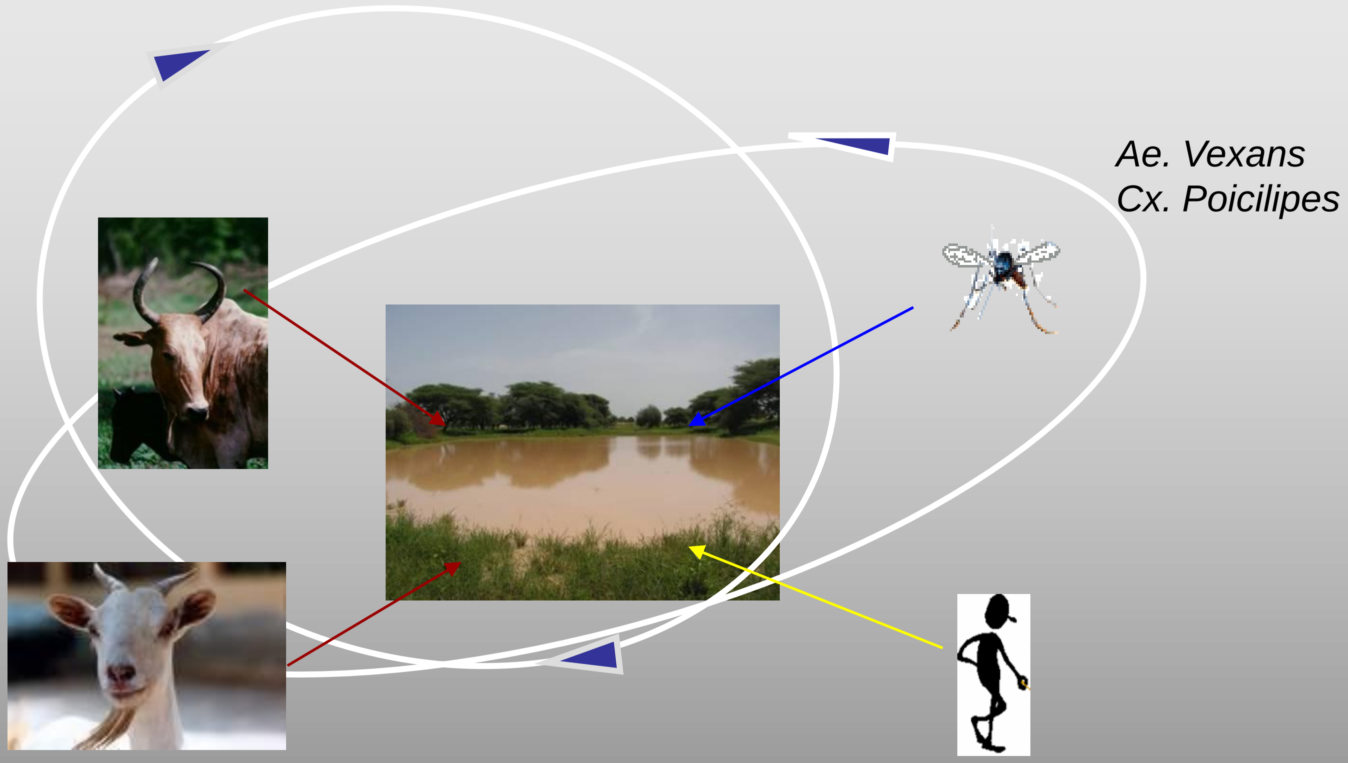
- Dry climate
- Low precipitation : 300 to 500 mm from July to October
- Shrubby vegetation



➢ A dense pond network

- Temporary ponds are flooded during the rainy season
- Ponds are not very deep
- A high variability of water level

Cycle of RVFV Transmission



Aim of the study / landscape approach :

- Study the relationship between epidemiological data and landscape variables

→ To identify landscape variables that can explain the RVF incidence in a pest control perspective

DATA

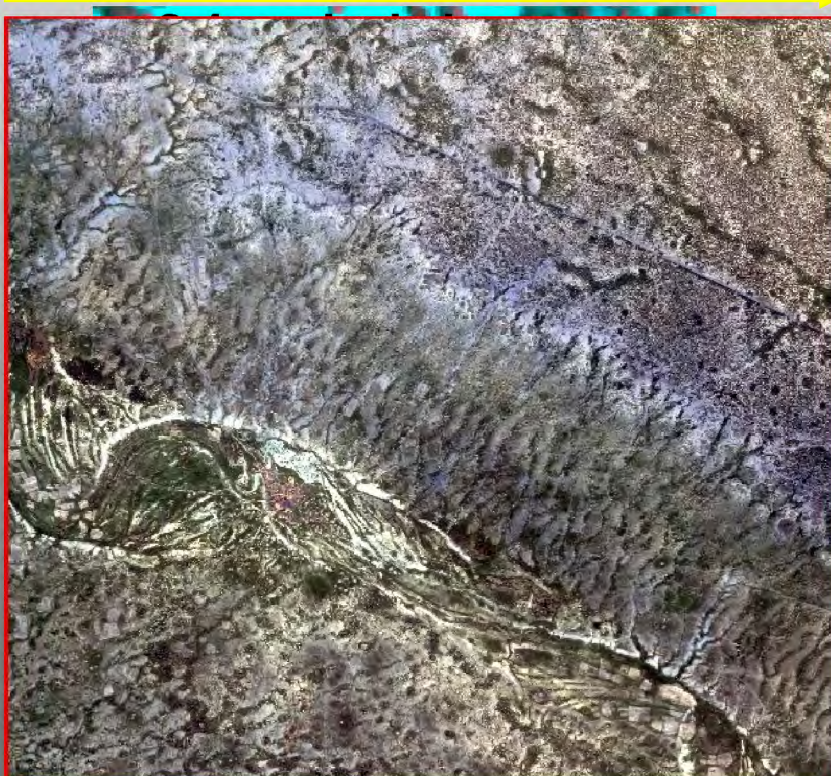
1) **Satellite Image acquisition : Quickbird sensor**

2) **Sheep serologic incidence Data** collected in 2003

3) **Field vegetation surveys**

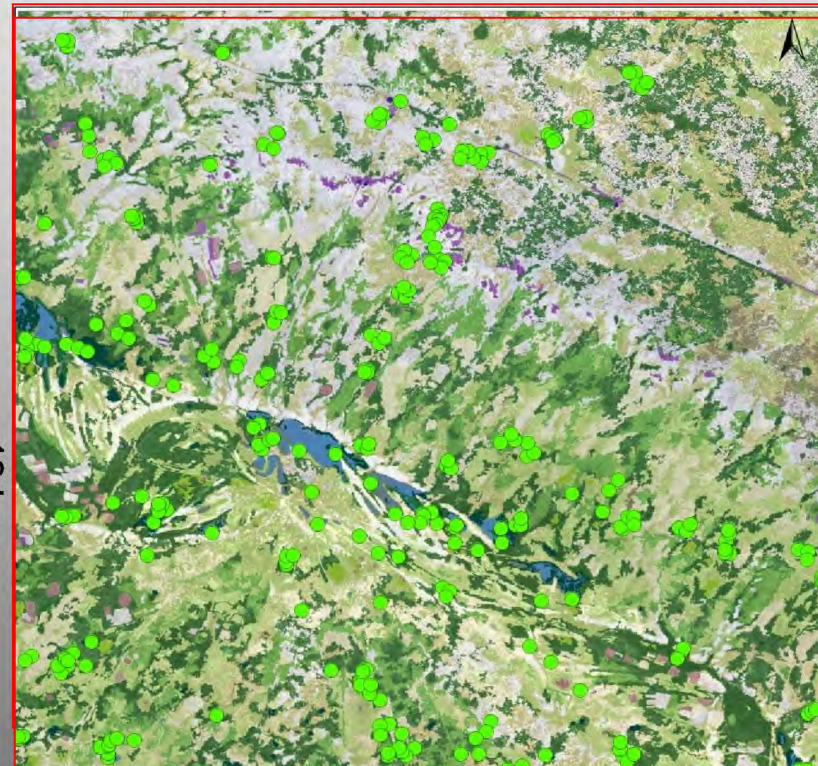
(Bands : B, V, R,PIR)

13 km



13 km

Date acquisition : 5th august 2004



293 field vegetation data

8 compounds
Sheep seroconvertion rate

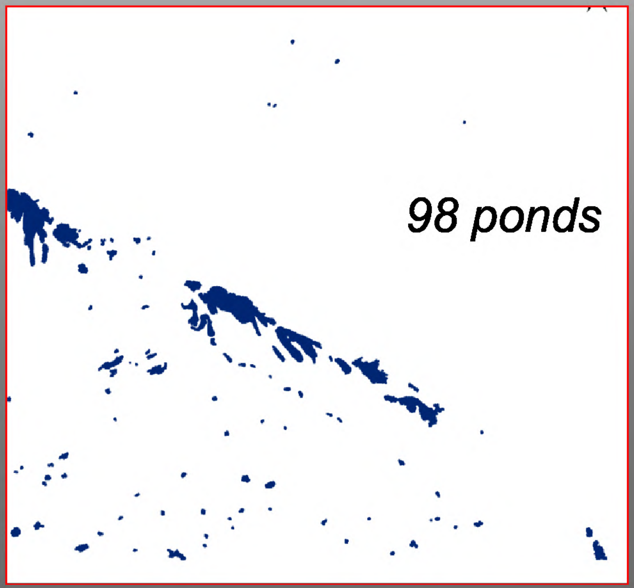
2.1 Pond map

Spatial distribution of ponds

Water index -> NDWI :
[V ± NIR] / [V + NIR]

(Mac Feeter, 1996)

- 98 ponds or water bodies were detected.
- Smallest surface : 195 m^2



2.2) Vegetation maps

Methodology

Step 1

Image segmentation

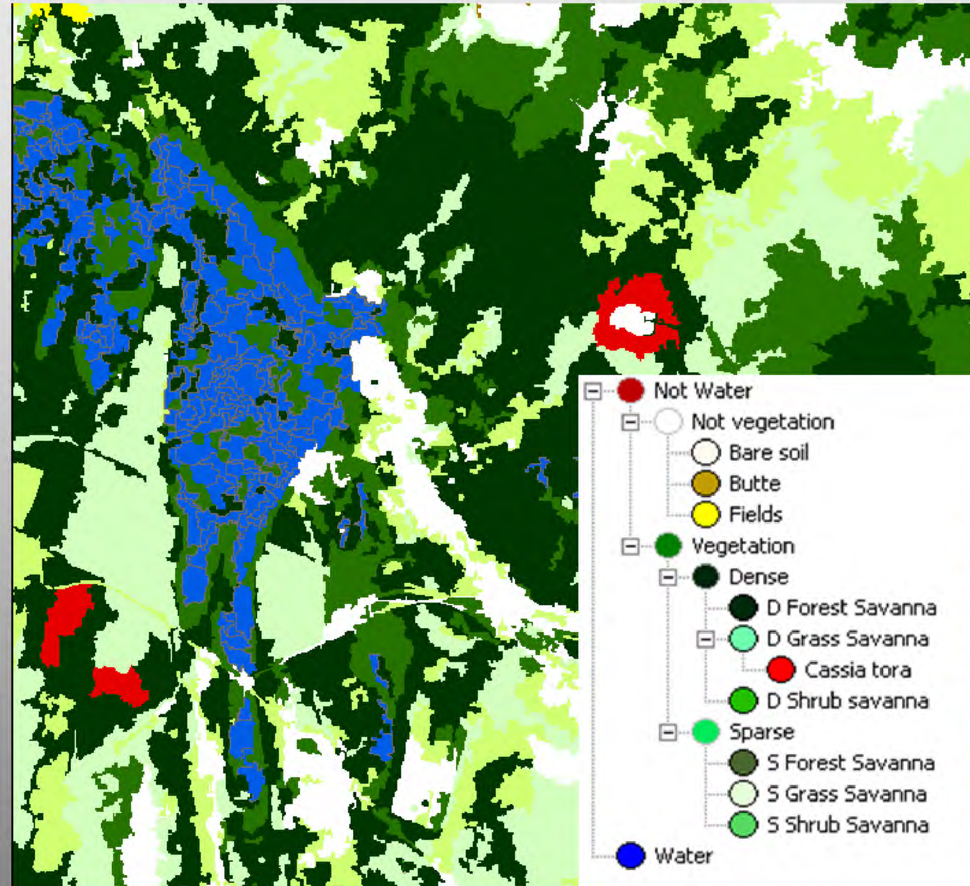
Step 2

Supervised classification

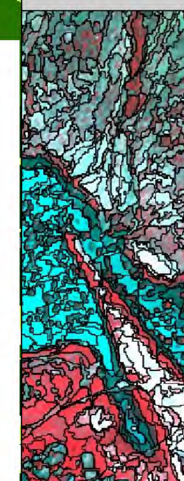
-Nearest neighbour classification algorithm
-Selection of training sites (125 field data)
-Vegetation map composed by 11 classes :

Step 3

Accuracy assessment



haracterize
pond



	Sparse forest savana	Dense grass savana	Cassia tora	Culture	Bare soil	Sparse shrub savana	Laterite butte	Dense shrub savana	Dense forest savana	Sparse grass
Producer	0,65	1,00	0,44	0,54	0,98	0,50	0,80	0,99	0,89	0,99
User	0,88	0,31	1,00	1,00	0,44	0,99	1,00	1,00	0,87	0,77
Overall Accuracy	0,78									
KIA	0,75									

The Global mean accuracy was 78% and Kappa index of 0.75 which corresponds to a quite good agreement between the two data sets

3.1 Landscape variables definition

1) **Water pond area**

2) **Pond location**
(inside/ outside the main stream)

(Chevalier et al., 2005)

Areas with a high density of ponds are more at risk → **3) Pond density Index (PDI)** (radius = 1 km)

(Chevalier, 2005)

(Ba Yamar et al.2005)

Ponds covered with vegetation are habitats favourable to the mosquitoes, as breeding sites and rest areas → **4) Water Vegetation Index (WVI)**

(Becker, 1989 ; Clements, 1999)

Vegetation is known having impacts on mosquitoes presence and displacement → **Landscape Closure Index (LCI)**

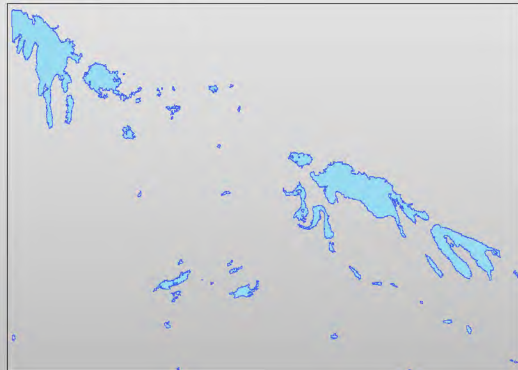
5) **LCI - 100 m**
6) **LCI - 500 m**
7) **LCI - 1000 m**

(Clements, 1999)

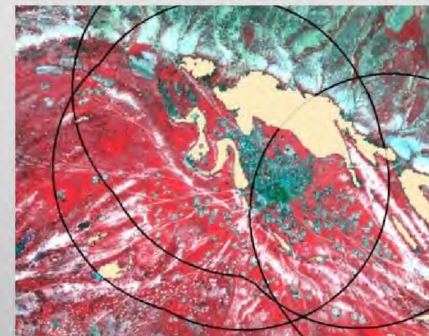
(Ba Yamar et al.2005)

3.2 Landscape variables calculation

Pond map



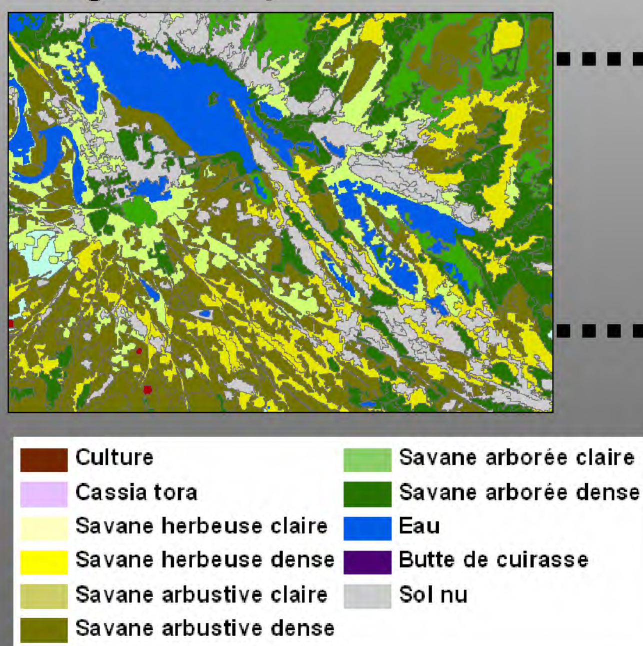
For each pond:

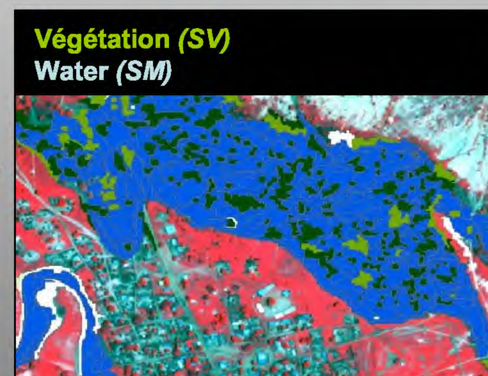


Pond density index (*PDI*)
(within a 1 km radius)

$$PDI_i = \sum_{j=1}^{n} \frac{1}{SW_j}$$

Vegetation map





Water vegetation Index (*WVI*)

$$WVI_i = \frac{SV_i}{SW_i}$$

Landscape closure Index (*LCI*)

$$LCI_i = \frac{CL_i}{OL_i + MOL_i}$$

3.3 Statistical analysis

Relations between landcape variables and serologic incidence

Explanatory variables

Landscape indices

- Linear regresssion to test the relation between variables

Statistical Analysis
A simple logistic regression model

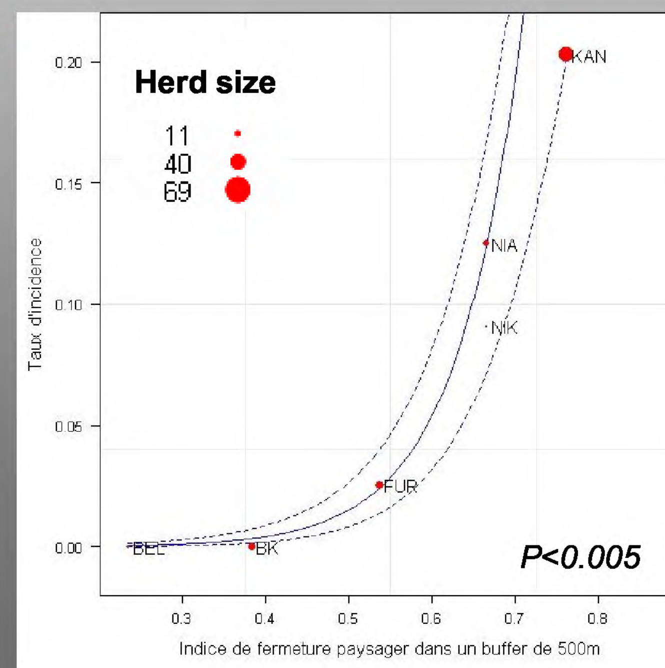
AICc index

	Model	Deviance	Parameters	*AICc*	Δ*AICc*
1	IF_500m	2,76	3	25,4	0
2	IF_100m	3,71	3	26,3	0,95
3	IF_1000m	7,43	3	30,1	4,67
4	IF_500m + IDM	1,81	4	33,8	8,39
5	IF_500m + Surface	2,41	4	34,4	8,98
6	IF_500m + Ferlo	3,09	4	35,1	9,66
7	Ferlo + IVM	3,29	4	35,3	9,87
8	IF_100m + IDM	3,85	4	35,8	10,43
9	IF_100m + Surface	4,04	4	36	10,61
10	1000m + IDM	4,17	4	36,1	10,75

Dependant variables

RVF serologic incidence per compound
- 610 small ruminants

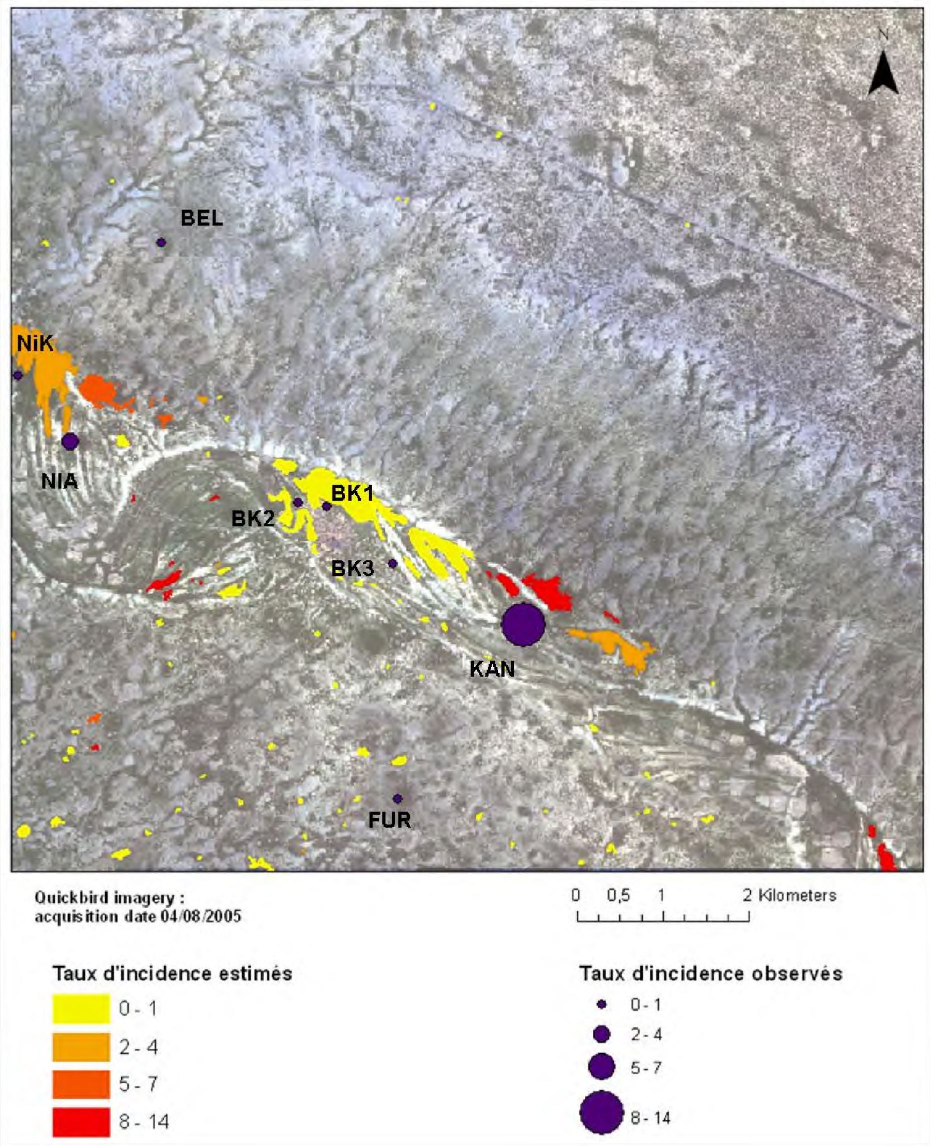
Spatial autocorrelation test (Indice = 0.03)



The more the vegetation is dense, the more the serological incidence rate in a herd is high

3.3 Statistical analysis

Risk map of RVF serological incidence



- A spatial heterogeneity of the RVF risk transmission
- The RVF risk transmission is greater in the main stream of the Ferlo river
- Notes a significant effect of the « vegetation density in a 500 m radius around the pond » on the RVF transmission risk

-> 500 m = coincides with the dispersion scale of mosquitoes *(Ba Yamar et al., 2005)*, but also with the average distance between the pond and the location of compounds *(Pin-Diop, 2007).*

- A low number of observations
- An indirect index (data on mosquito abundance were not available)

-> More field surveys are required to confirm the results

Conclusions and perspectives

❖ *Conclusions*

- Quickbird imagery : potentialities to characterize the habitat of the insects with a low dispersal capacity

- Vegetation influence on the spatial heterogeneity of the disease distribution

- Importance of the landscape structure (habitat connectivity) on the disease risk transmission.

❖ *Perspectives*

- Test of a vegetation index (e.g. NDVI)

- Test of imagery with lower spatial resolution with lower costs (e.g. SPOT5)

- Provide regional RVF transmission risk maps as a support for decision makers


Thanks for your attention