



**Grant agreement no. 243964**

**QWeCI**

**Quantifying Weather and Climate Impacts on Health  
in Developing Countries**

**Milestone 5.3.e: GIS HEWS conceptual model**

Start date of project: 1<sup>st</sup> February 2010

Duration: 42 months

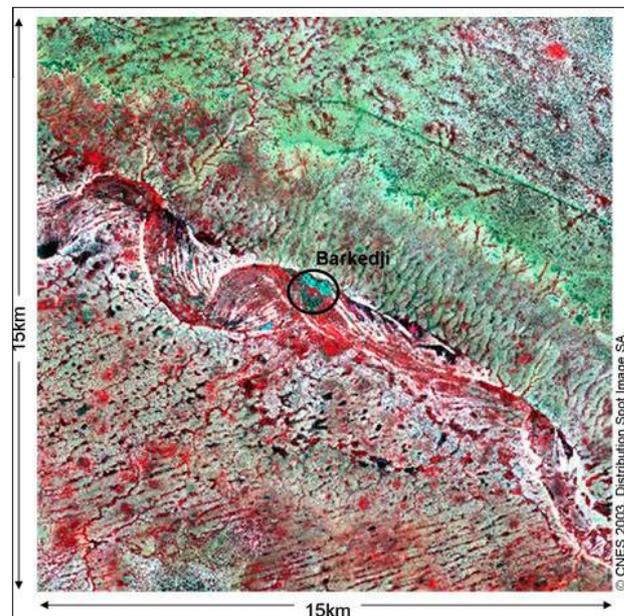
**Lead contractor:** UCAD  
**Coordinator of milestone:** UCAD  
**Evolution of milestone**

**Due date :** M33  
**Date of first draft :** 8 December 2012  
**Start of review :** 9 December 2012  
**Milestone accepted :** 14 December 2012

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

## Introduction

The QWeCI project (Quantifying Weather and Climate Impacts on Health in Developing Countries) funded by FP7 from European Commission is mainly focusing on how to evaluate the use and awareness of predictions and projections of atmospheric variability on time scales of weeks, months and seasons (weather), up to decades (climate) for quantification of health impacts in targeted countries. In Senegal, the WP 5.3 of QWeCI is dedicated to the pilot project, and this study is focusing in the Barkedji Health and Environment Observatory (figure 1).



**Figure 1: The Barkedji Health and Environment Observatory, study area of the QWeCI project in Senegal.**

### 1. Diseases under investigations

Among vector borne diseases in Senegal, RVF and malaria are both a strong concern of researchers and decision makers. With regards to the QWeCI project, the two diseases are under investigations, namely Rift Valley fever and malaria.

#### 1.1- Rift valley fever

Rift Valley fever (RVF) is an acute fever causing viral disease that affects domestic animals (such as cattle, buffalo, sheep, goats, and camels, among others), and humans. RVF is most commonly associated with mosquito-borne epidemics during years of unusually heavy rainfall events. The RVF virus, a member of the genus *Phlebovirus* in the family *Bunyaviridae*, is responsible for the disease. Veterinary officers in Kenya first reported RVF among livestock in the early 1900s. Numerous epidemic/epizootic outbreaks have been reported periodically in many African countries during the past 30 years (Meegan 1979; Hoogstraal et al., 1979; Arthur et al. 1993; Jouan et al., 1988; Digoutte and Peters 1989; Zeller et al., 1997; Linthicum et al., 1999; Nabeth et al., 2001; Woods et al., 2002; Sissoko et al, 2009; Caminade et al, 2011; El Mamy et al, 2011). The virus has been recently located for the first time outside of

the African continent, in Saudi Arabia and Yemen during 2000-2001 (Miller et al., 2002; Jupp et al., 2002).

In Senegal the RVF outbreak occurred in 1987 (Meegan et al, 1988; Jouan et al, 1989; Digoutte et Peters, 1989; Ndione et al, 2005). After this outbreak, entomological studies were conducted in Senegal from 1991 to 1996 to identify the sylvatic vectors of the virus (Fontenille et al., 1998). In 1998, following the re-emergence of the RVF virus in south eastern Mauritania and in the Diawara region, an entomological survey was undertaken at the northern border of Senegal to assess the extent of the virus circulation. During this study (Diallo et al., 2000) isolated the virus for the first time from *Culex poicilipes*.

Over Senegal and southern Mauritania, RVF epidemics (Ndione et al, 2003; Ba et al., 2005), do not seem to follow the same relationships as that over East Africa (Davies et al, 1985; Linthicum et al, 1999; Anyamba et al, 2001). The spatio-temporal distribution of discrete rainfall events (such as squall-lines) during the rainy/summer monsoon season (contrary to the seasonal amount of total rainfall over East Africa) appears to be the confounding parameter for mosquitoes' production (Ndione et al., 2003). In accordance with the work of Bâ et al. (2005), Mondet et al. (2005), Ndione et al. (2008), rainfall frequency/periodicity (including timing of intra-seasonal variability) is a key factor modulating *Ae. vexans* population abundance.

Today, new scientific challenges have dealing with health early warning systems, including GIS and remote sensing (Lacaux et al, 2007).

## **1.2- Malaria**

Malaria is an anopheline-borne infectious disease of humans caused parasite of the genus Plasmodium. Five species of Plasmodium can infect and be transmitted by humans. The vast majority of deaths are caused by *P. falciparum* while *P. vivax*, *P. ovale*, and *P. malariae* cause a generally milder form of malaria that is rarely fatal. The zoonotic species *P. knowlesi*, prevalent in southeast Asia, causes malaria in macaques but can also cause severe infections in humans. Malaria is prevalent in tropical and subtropical regions because rainfall, warm temperatures, and stagnant waters provide habitats ideal for Anopheles larvae. Disease transmission can be reduced by preventing mosquito bites by distribution of mosquito nets and insect repellents, or with mosquito-control measures such as spraying insecticides and draining standing water.

Over the past five years, considerable efforts have been made for the implementation of effective control strategies. Thus, significant progress has been made in the control of malaria in sub-Saharan African countries. This success was attributed to the diversification of control measures used, the improved treatment and better diagnosis methods. However, the decrease tendencies were short-lived to have been disrupted by the recent "rebound effects" evidenced by a rapid increase in several contexts in sub-Saharan Africa. The hypotheses to explain this unexpected situation takes into account the loss of population immunity associated with climatic and environmental changes especially in arid areas. In fact, several studies suggest that climate change would lead to an increase in malaria cases since it is estimated that among the tropical diseases, malaria is the most affected by recent climate changes. These changes in the local physical environment (rainfall, temperature, water surface, humidity, vegetation, etc.) expected under different scenarios would affect the biology and ecology of vectors (survival, vector competence, etc.).

With regards to Barkedji, Lochuarn et al (1995), Lemasson et al (1997) and Dia (2007) described the malaria profile in this area thanks to fields studies; more recently, Dia et al (2010) gave some new findings dealing with land use and cover changes.

## 2. Identification of Geospatial layers

In the Barkedji Health and Environment Observatory (BHEO), different data have been collected since the beginning of the project. In fact, there is a high concentration of in-situ measurements in BHEO covering various sectors: climate, hydrology, water quality, vegetation, land use and land cover changes, veterinary survey (herd's concentration, serosurvey, and ruminants' parks), malaria incidence, entomological, viral surveys and social pastoral practices investigations...

In addition, before the QWeCI project, some others information were available in this area, and this platform will be an opportunity to pool and enhance all these valuable data. Two DMCs (Data conceptual model) are posted in annex to this milestone for illustrating two components of the HEWS conceptual model. In addition a screen capture of ArcView different layers are available also in annex.

The table below gives an overview of geospatial layers available.

<b>Themes</b>	<b>Layers</b>
<i>Climate</i>	<i>Map of raingauges network</i>
<i>Hydrology</i>	<i>Map of ponds (water bodies)</i>
<i>Water quality</i>	<i>Sites for water quality sampling</i>
<i>Land use and land cover change</i>	<i>Map of soils Land use</i>
<i>Veterinary survey</i>	<i>herd's concentration and ruminants' parks</i>
<i>Malaria incidence</i>	<i>Data available for the six pilot villages selected in the QWeCI project</i>
<i>Entomological sites</i>	<i>Sites where entomological captures are realised</i>
<i>Pastoral practices</i>	<i>Information dealing with transhumance, the length of their stay in Barkedji, the origin of their</i>
<i>Human settlements</i>	<i>Villages, cities, etc</i>

## 3. Identification of tools

Two options of tools are available. The HEWS can be developed by using **Open source soft** or it can be based on **Licensed softs**, like ArcView or ArcGIS. Based on the experience that CSE had these last years, because we have developed several tools for our partners<sup>1</sup> like this expected one, it's better to do it with open source soft. We take this choice because open source tool can be handled more easily by stakeholders themselves, and they don't require

<sup>1</sup> CSE had developed several tools like this one for different projects in Senegal, like PRODAM, *Zones humides Ferlo (Wetlands in Ferlo area)*, *INFOCLIM (Plateforme participative d'information pour l'adaptation des communautés vulnérables aux changements climatiques)*, *PADERCA (Projet d'appui au développement rural en Casamance)*, *BDU-Louga (Base de données urbaines-Louga)*

purchasing any license to run the software. In the other case if, it is developed using a soft like ArcGis or ArcView, whatever the issue you need to license...

The software will be developed with Delphi and TatuGIS software is an instrument for structuring and communicating information. The software is developed by the *Centre de Suivi Ecologique* (CSE). The instrument will be equipped with the main functional characteristics of a GIS enabling the display of thematic layers and base already available as well as remote sensing data. The visual representation of data in the form of thematic maps is certainly easier to communicate than a set of tables and figures. Friendly and easy to use, the system has the characteristics specific to environmental monitoring: location, information about an object, data modification and pre-treatment in the form of thematic mapping spatial analysis and statistics.

It does not have all the computer components of GIS because limited to viewing the digital capture, and certain pre-programmed analyzes. The data below will structure the base: land use and land cover changes, socio-economy issues and health components.

## Conclusion

The HEWS designed in the WP5.3 of the QWeCI project will give for local stakeholders but also for African health information systems, agencies and organizations over West Africa a panoply of additional products in support of appropriate measures to apply in regions under threats.

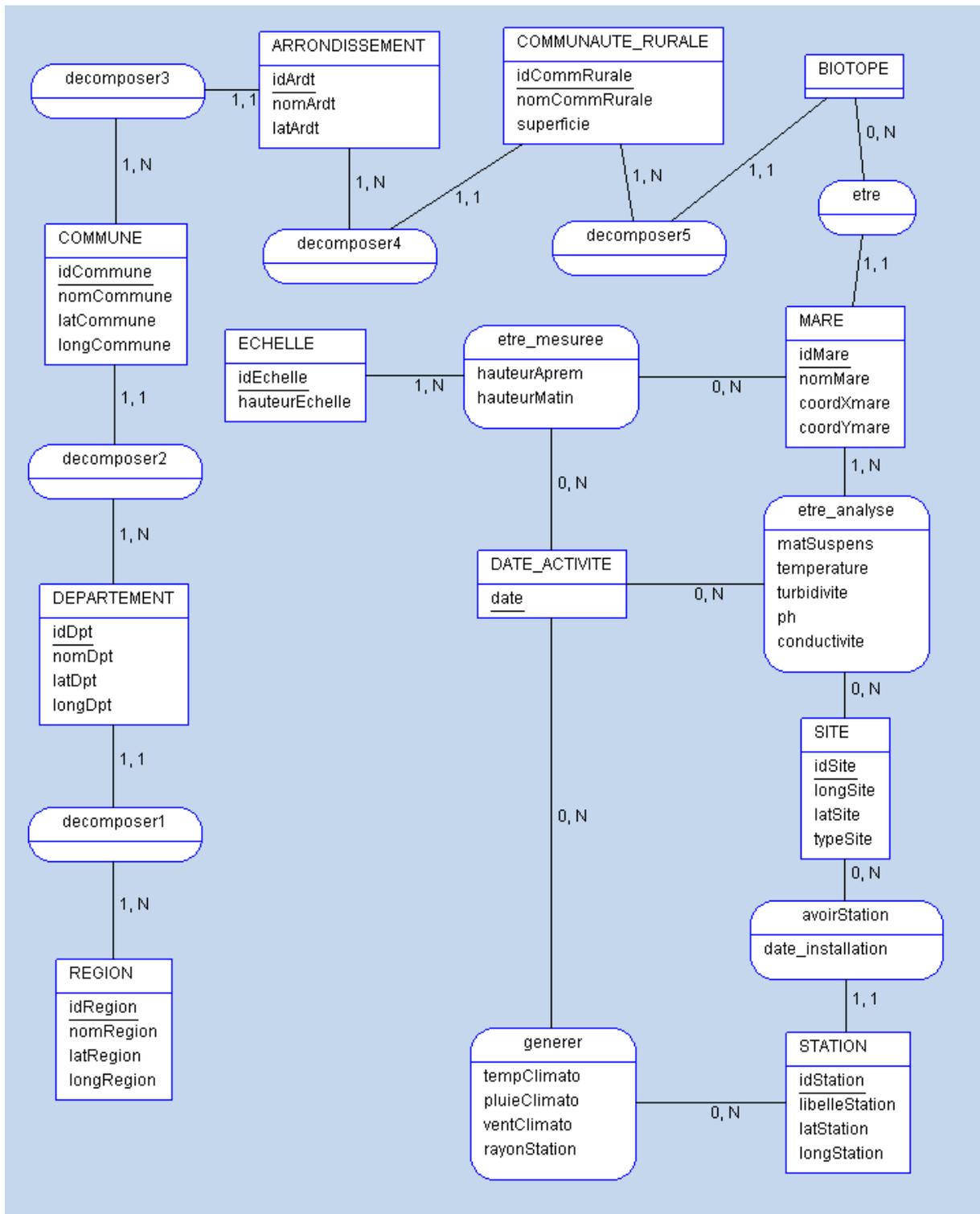
## References

- Arthur R.M.S. Sharkawy El, Cope S. E., Botros B. A., Oun S., Morrill J. C., Shope R. E., Hibbs R. G., Darwish M. A., Imam I.Z.E., 1993. Recurrence of Rift Valley fever in Egypt. *Lancet* 342: 1149D1150.
- Anyamba A., Linthicum K.J., Tucker C.J., 2001. Climate-disease connections: Rift Valley Fever in Kenya, *Cad Saude Publica*, 17(suppl): 133-140.
- Ba Y., Diallo D., Kebe C.M.F., Dia I., Diallo M., 2005. Aspects of bioecology of two Rift Valley Fever virus vectors in Senegal (West Africa): *Aedes vexans* and *Culex poicilipes* (Diptera: Culicidae), *Journal of Medical Entomology*, 42(5): 739-750.
- Caminade C., J.A. Ndione, C.M.F. Kebe, A. E. Jones, S. Danuor, S. Tay, Y.M. Tourre, J.P. Lacaux, J.B. Duchemin, I. Jeanne, A.P. Morse. Mapping Rift Valley Fever and Malaria risk over West Africa using climatic indicators. *Atm. Sc. Lett.*, 12: 96-103 (2011).
- Davies F.G., Linthicum K.J., James A.D., 1985. Rainfall and epizootic Rift valley fever. *Bulletin of the World Health Organisation*, 63(5): 941-943.
- Dia I., 2007. La transmission vectorielle du paludisme In *Palu Info*, n°005, 10-11
- Dia I., Samba B., Konate L., Fontenille D., 2010. Population structure of newly established *Anopheles funestus* populations in the Senegal River basin using paracentric chromosomal inversions, *Acta tropica*, doi:10.1016/j.actatropica.2010.02.008
- Diallo M., Lochouart L., Ba K., Sall A.A., Mondo M., Girault L., Mathiot C., 2000. First isolation of the Rift Valley fever virus from *Culex poicilipes* (Diptera: Culicidae) in nature, *American Journal of Tropical Medicine and Hygiene*, 62: 702-704.
- Digoutte J.-P., Peters C.J., 1989. General aspects of the 1987 Rift Valley fever epidemic in Mauritania. *Research in virology*, 140: 27-30.
- El Mamy A.B.O., Baba M. O., Barry Y., Isselmou K., Dia M.L., Ba H., Diallo M.Y., El Kory M.O.B., Diop M., Lo M.M., Thiongane Y., Bengoumi M., Puech L., Plee L., Claes F., de La Rocque S., Doumbia B., 2011 : Unexpected Rift Valley Fever Outbreak, Northern Mauritania. *Emerging Infectious Diseases*, 17 (10), 1894-1896

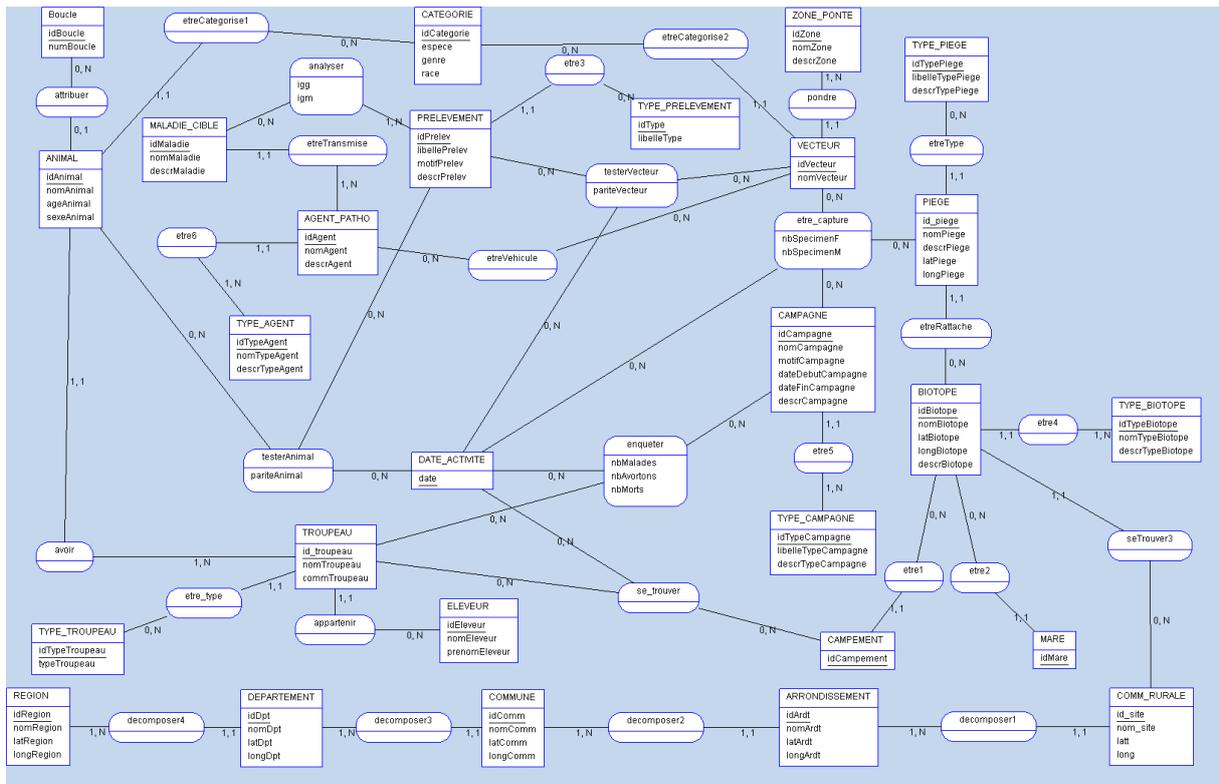
- Fontenille D., Traore-Lamizana M., Diallo M., Thonnon J., Digoutte J.-P., Zeller H.G., 1998. Nouveaux vecteurs de la fièvre de la vallée du Rift en Afrique de l'Ouest. *Emerging Infectious Diseases*, 4: 289-293.
- Hoogstraal H., Meegan J., Khalil G.M., Adham F.K., 1979. The Rift Valley fever epizootic in Egypt 1977-78. 2. Ecological and entomological studies. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 73(6): 624-9.
- Jouan A., Le Guenno B., Digoutte J.-P., Philippe B., Riou O., Adam F., 1988. An RVF epidemic in Southern Mauritania, *Annales de l'Institut Pasteur / Virologie*, n°139, pp. 307-308.
- Jouan A., Coulibaly I., Adam F., Philippe B., Riou O., Le Guenno B., Christie R., Merzoug N.O., Ksiazek T., Digoutte J.P., 1989: Analytical study of a Rift Valley fever epidemic. *Research in virology*, 1989, **140** : 175-186.
- Jupp P.G., Kemp A., Grobbelaar A., Leman P., Burt F.J., Alahmed A.M., Al Mujalli D., Al Khamees M., Swanepoel R., 2002. The 2000 epidemic of Rift Valley fever in Saudi Arabia: mosquito vector studies. *Medical and Veterinary Entomology*, 1: 245-252.
- Lacaux J.-P., Tourre Y.-M., Vignolles C., Ndione J.-A., Lafaye M., 2007. Ranking Ponds from High-Resolution Remote Sensing: application to Rift Valley Fever Epidemics in the Ferlo Region (Senegal). *Remote Sensing of Environment*, 106: 66-74.
- Lemasson et al (1997), Comparison of behaviour and vector efficiency of *Anopheles gambiae* and *An. Arabiensis* (Diptera: culicidae) in Barkedji, a Sahelian area of Senegal, *Journal of medical entomology*, 34 (4): 396-401
- Linthicum K.J., Assaf A., Compton J.T., Kelley P.W., Myers M.F., Peters C.J., 1999. Climate and satellite indicators to forecast Rift Valley Fever epidemics in Kenya. *Science*, 285: 397-400.
- Lochuarn L., Dia I., Coluzzi M., Faye O., Robert V., Simard F., Lemasson J.J., Fontenille D., 1995. Les vecteurs du paludisme au Sénégal : une systématique en évolution, *Bulletin de la Société Médicale d'Afrique Noire de Langue française*, 55-58
- Meegan J.M., Hoogstraal H., Moussa M.I., 1979. An epizootic of Rift valley fever in Egypt in 1977. *Veterinary Record*, 105(6): 124-5.
- Meegan J.M., Bailey C.H., 1988. Rift valley fever. *Arboviruses Epidemiology and Ecology* (ed. T.P. Monrath), CRC Press, Boca Raton, 51-76.
- Mondet B., Diaité A., Ndione J.-A., Fall A.G., Chevalier V., Lancelot R., Ndiaye M., Ponçon N., 2005a: Rainfall patterns and population dynamics of *Aedes (Aedimorphus) vexans arabiensis*, Patton 1905 (Diptera: Culicidae), a potential vector of Rift Valley Fever virus in Senegal. *Journal of Vector Ecology*, 30: 102-106.
- Miller B.R., Godsey M.S., Crabtree M.B., Savage H.M., Al-Mazrao Y., Al-Jeffri M.H., Abdoon A.M., Al-Seghayer S.M., Al-Shahrani A.M., Ksiazek T.G., 2002. Isolation and genetic characterization of Rift Valley fever virus from *Aedes vexans arabiensis*, Kingdom of Saudi Arabia. *Emerging Infectious Disease*, 8: 1492-1494.
- Nabeth P., Kane Y., Abdalahi M.O., Diallo M., Ndiaye K., Ba K., Schneegans F., Sall A.A., Mathiot C., 2001. Rift Valley fever outbreak in Mauritania in 1998: seroepidemiologic, virologic, entomologic, and zoologic investigations. *Emerging infectious diseases*, Nov-Dec. 7(6):1052-1054.
- Ndione J.-A., Besancenot J.-P., Lacaux J.-P., Sabatier P., 2003. Environnement et épidémiologie de la fièvre de la vallée du Rift (FVR) dans le bassin inférieur du fleuve Sénégal. *Environnement, Risques et Santé*, vol. 2, n°3, pp. 176-182.
- Ndione J.-A., Bicout D., Mondet B., Lancelot R., Sabatier P., Lacaux J.-P., Ndiaye M., Diop C., 2005. Conditions environnementales associées à l'émergence de la fièvre de la vallée du Rift dans le delta du fleuve Sénégal en 1987. *Environnement, Risques et Santé*, vol. 4, n° 2, S5-S10.
- Ndione J.-A., Diop M., Lacaux J.-P., Gaye A.Th., 2008. Variabilité intrasaisonnière de la pluviométrie et émergence de la fièvre de la vallée du Rift (FVR) dans la vallée du fleuve Sénégal : nouvelles considérations, *Climatologie*, vol. 5, pp. 83-97.
- Sissoko D, Giry C, Gabriele P, et al., 2009b : Rift Valley fever, Mayotte, 2007-2008. *Emerging Infectious Diseases*, **15**, 568-570.
- Woods C.W., Karpati A.M., Grein T., McCarthy N., Gaturuku P., Muchiri E., Dunster L., Henderson A., Khan A.S., Swanepoel R., Bonmarin I., Martin L., Mann P., Smoak B.L., Ryan M., Ksiazek T.G., Arthur R.R., Ndikuyeze A., Agata N.N., Peters C.J., 2002. An outbreak of Rift Valley fever in Northeastern Kenya, 1997-1998. *Emerging Infectious Diseases*, 8: 138-144.

Zeller, H. G., D. Fontenille, M. Traore'-Lamizana, Y. Thiongane, and J. P. Digoutte. 1997. Enzootic activity of Rift Valley fever virus in Senegal. *Am. J. Trop. Med. Hyg.* 56: 265D272.

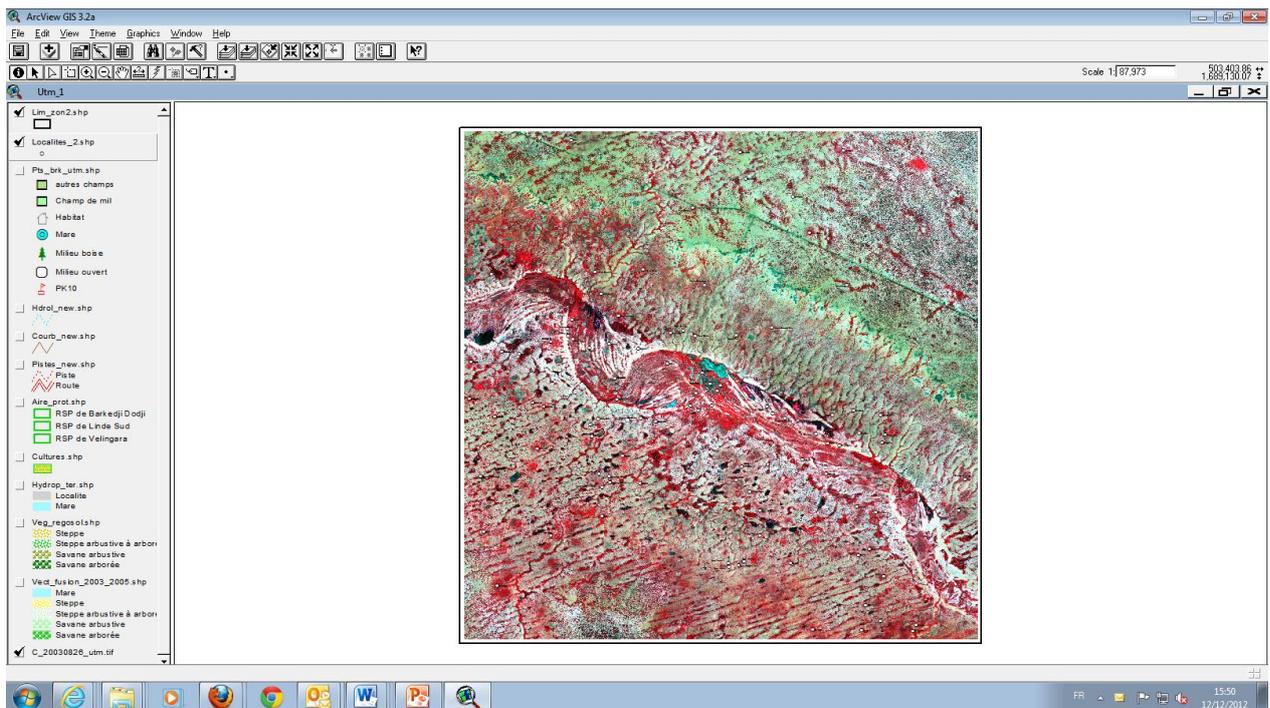
# *Annexes*



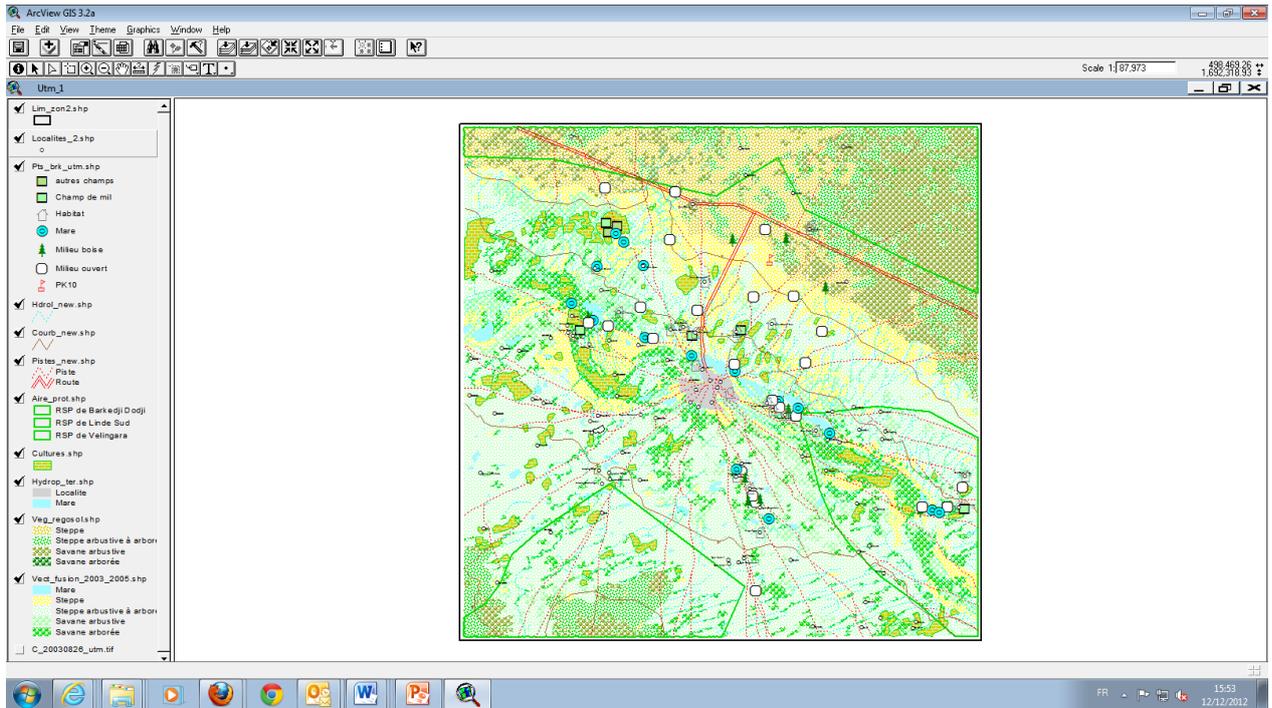
First step of DCM of climate and hydrological components of the HEWS



First step of DCM of entomological component of the HEWS



First screen capture of human settlements in the Barkedji Health and environment Observatory



Second screen capture of the Barkedji Health and environment Observatory; information dealing with vegetation, protected areas, ponds, entomological sites, trunks and slopes, etc.