Rift Valley Fever (RVF) Case Study – Dynamic Drivers of Disease in Africa: Ecosystems, livestock/wildlife, health and wellbeing

Update April 2014

Contents

Welcome note

Welcome to our latest update on the Rift Valley fever (RVF) case study being implemented in Kenya as a component activity of the Dynamic Drivers of Disease in Africa project. As well as creating awareness of our activities, we want to elicit feedback that we can use for their refinement.

One of our remarkable research outputs to date, produced as part of a graduate fellowship programme, is an ecological niche map for RVF in Kenya. The student involved, Dr Purity Kiunga, initiated the study by geo-referencing known RVF hotspots in Kenya and analysing them together with spatial datasets on precipitation, rainfall, soil types, land use and vegetation indices. The work has generated an RVF risk map with a better resolution than existing maps, and it will enable our team to undertake a comparison of RVF drivers at local and national scales.

This bulletin gives details on this and our other research activities, as well as our preliminary observations. It includes results from analyses of secondary data on climate and other spatial datasets. It also outlines preliminary results from entomological surveys to determine the distribution of mosquito vectors in the study sites. More work has also been done to sample rodents (mainly rats) from the study sites and screen them for important zoonotic pathogens.

I thank you for your interest in this study. Any suggestions and comments for the improvement of the study are welcome. Please send them to contact@driversofdisease.org

With best regards

Bernard Bett
Kenya country lead, Dynamic Drivers of Disease in Africa Consortium; scientist/coordinator, RVF case study, International Livestock Research Institute (ILRI)

Research updates

We first present updates from research activities in the case study sites before giving a summary on findings from ecological niche modelling for RVF.

Updates from research activities from the case study sites
The case study sites and analysis of secondary data

The study uses two irrigation schemes in Tana River district (Hola and Bura) and a pastoral rangeland (Ijara) to represent areas that have had substantial and slower changes on land use. The Bura irrigation scheme has a total acreage of 10,000 with 7,000 being available for cultivation, while Hola has an area of 3,500 acres. Figure 1 shows the location of these sites as well as the relative distribution of sites that have been used for mosquito, small mammals, animal and human sampling.
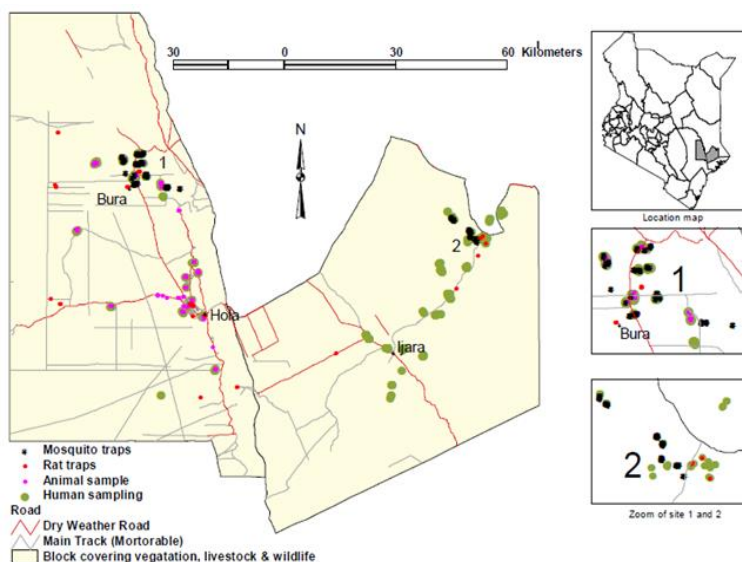

Figure 1: The case study area showing the distribution of sampling sites

Secondary data on climate, land use, soil types, and human population density from the case study sites from 1970s to the present have been processed and analysed to characterise the study sites. The analyses suggest that 72% of the land area falls under arid environments while 28% falls under very arid conditions. The major soils found in the sites are haplicsolonetz, eutricvertisols and eutricplanosols. These soils have poor draining properties and they are known to be prone to inundation, leading to the development of mosquito breeding sites. The average daily temperatures are 34 and 23°C for sites 1 and 2, respectively.

- *Mohamed Said, ILRI*

Participatory rural appraisals generate information on wealth categories, ecosystem types and services, and risk practices

Focus group discussions, key informants interviews and narratives have been used to gather information on communities' livelihood patterns, wealth categories, perceptions on spatio-temporal changes on ecosystem services and variation on the incidence of infectious diseases in people and livestock. Methods that have been

used for focus group discussions include semi-structured interviews, proportional piling, time lines, participatory mapping and transect walks. In addition, photographs of the common vegetation types and land use patterns were taken and used together with participatory mapping to support elicitation of information on ecosystem changes. Plate 1 demonstrates some of the focus group discussions held where proportional piling (photo 1) and participatory mapping (photo 2) methods were applied.

Plate1: A group of women participating in proportional piling (photo 1) and some men being engaged on the development of a village resource map, aided by pictures of the local vegetation and land use cover (photo 2). Most of the focus group discussions were stratified by gender (both photos from Sally Bukachi)

On wealth ranking, a majority (90%) of the participants interviewed considered themselves as falling in the middle and poor categories based on criteria agreed upon with them (which includes ownership of a range of assets). Data collected suggest that people that fall in the middle class can afford up to two meals per day while those in the low/poor category could afford only one maize meal per day. In both cases, meals afforded are of limited variety. Data collected further show that people in the middle and poor categories generally work as labourers in irrigated farms or raised income through the sale of charcoal, firewood or water fetched from the local streams. They therefore interact more with their ecosystems and were more likely to get exposed to infectious diseases than the rich. The rich were perceived as being able to access nutritious food as well as reliable medical services.

Types of ecosystems and ecosystem services that the local communities could identify and value varied between the study sites. The Somali pastoralists in Ijara highly valued conservancies because they are also used as dry season grazing sites. One of the groups interviewed in the site indicated that the conservancies also raised various types of antelopes that buffered their livestock against predators including lions. In irrigated areas, water, food crops, firewood, charcoal and building poles from *Prosopis juliflora* shrubs were identified as being the most common and important ecosystem services. Some of the disservices that were highlighted here include exposure to agrochemicals used in the farms, upsurge in the population densities of rodents, baboons and birds that destroyed crops. Farmers often guard their farms against marauding baboons until late in the evenings, exposing themselves to mosquito bites depending on the activity periods of these vectors.

Human diseases that were identified as being prevalent in irrigated areas include malaria, bilharzia, typhoid fever, AIDS, swelling of the lymphs with or without wounds (mostly from working in flooded farms barefooted), high blood pressure and cancers (which the locals attributed to exposure to agrochemicals). In Ijara, human diseases that were perceived as being prevalent include malaria and brucellosis. There was not much difference in the types of livestock diseases identified by area. Those commonly mentioned included trypanosomiasis, contagious caprine plueropneumonia, contagious bovine pleuropneumonia, tick-borne

diseases, foot and mouth disease, orf and mange. RVF was also mentioned in Ijara as an emerging disease that affected both humans and livestock. Participants from Bura and Hola do not have good knowledge on RVF.

- *Salome Bukachi, Institute of Anthropology, Gender and African Studies, University of Nairobi*

Household surveys generate data for determining the prevalence of zoonotic pathogens in livestock and people and factors that promote transmission of zoonotic diseases

A total of 1,100 households have been randomly selected and used for questionnaire surveys and blood sampling of both livestock and humans in irrigated and non-irrigated areas. Questionnaire surveys were used to generate data on risk predictors, including practices that promote transmission of zoonotic diseases from livestock to people.

Livestock sampled include cattle, sheep and goats. Blood samples were obtained from the jugular veins using vacutainers; part of the sample was kept in EDTA as whole blood while the other was kept in plain tubes for serum preparation. The same approach was used while sampling humans – plate 2 illustrate these sampling activities. Ethical approvals for this work were obtained from ILRI (for animal sampling) and African Medical Research Foundation (for human sampling).
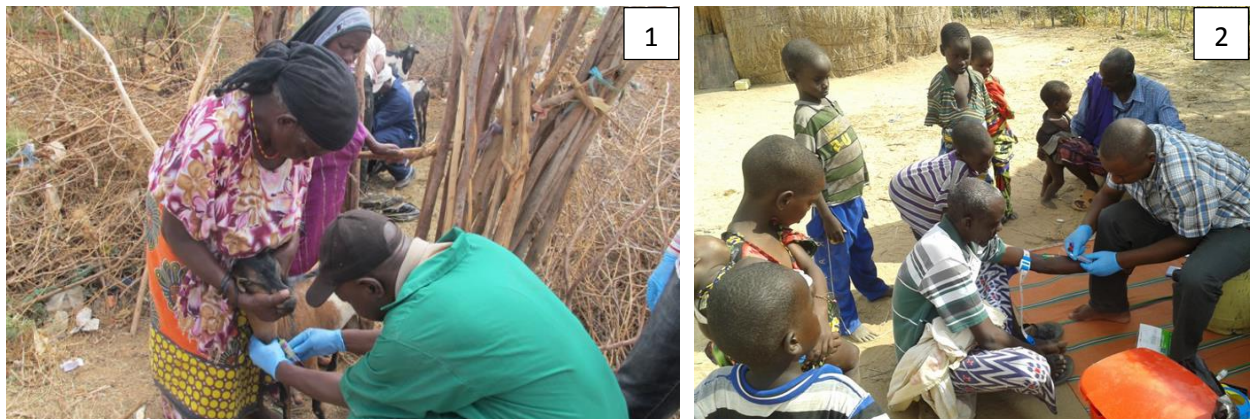

Plate 2: Livestock and human blood sampling illustrated in photos 1 and 2, respectively (photo 1 from Bernard Bett and photo 2 from Damaris Mwololo)

A total of 2,848 animals comprising 599 (21%) cattle, 1383 (49%) goats and 867 (30%) sheep have been sampled in Bura and Hola. For human sampling, a total of 1,092 samples were collected.

Samples collected have already been screened for RVF and brucellosis using respective ELISA tests and the results obtained are being verified. For livestock data further screening for Q fever and leptospirosis is set to start while for human samples, more tests will be done for arboviruses (West Nile virus, chikungunya virus and Dengue fever virus) at KEMRI.

Blood sampling in selected hospitals to determine pathogens that cause febrile infections in people, the relative contribution of zoonotic agents to, and risk factors for, these diseases

Blood samples are being collected from patients who visit local hospitals in Bura, Hola, Ijara and Sangailu health centres with current or history of fever over the last 14 days (with or without headache, exhaustion, muscle pain, joint pains, back ache, nausea and vomiting) and screened to determine causes of such infections. This will involve clinicians and laboratory technicians from these hospitals. These officers have been trained on techniques that should be used for sample collection (Plate 3).

Plate 3: Training of a clinical officer and a laboratory technician in Ijara health centre on methods for human sampling in hospitals (photo from Bernard Bett)

- *Damaris Mwololo and John Muriuki, College of Agriculture and Veterinary Sciences, University of Nairobi*

Entomological surveys indicate that irrigation promotes the development of primary vectors of RVF and other arboviruses

Entomological surveys have been done to compare the density and distribution of mosquitoes in irrigated and non-irrigated sites. In the irrigated areas, Bura irrigation scheme was used for intensive entomological surveys because it is larger and has more farming activities than Hola. Two surveys have been done, both during the dry season. The first survey was done during the inactive phase of irrigation when there was no water in irrigation canals or farms while the second was done when active irrigation had commenced. These surveys covered all the ten villages in the Bura irrigation scheme. Within each village, traps were deployed adjacent to irrigation canals, cultivated fields and residential areas (residential areas comprise clusters of about 200 households). At the same time, mosquito sampling was done in two non-irrigated sites. One of these was Murukani village, located 15 km from Bura irrigation scheme, where farming is entirely dependent on rainfall, and the other was Sangailu in Ijara, which is about 200 km away from Bura, where pastoralism is the key livelihood activity.

Sampling of adult mosquitoes was done using CDC light traps baited with carbon dioxide. Some of the procedures used for trapping, sorting and identification are illustrated in Plate 4. Larvae were also collected from breeding habitats, reared and identified after emerging as adults.

Data obtained in these surveys suggest that when irrigation is active, the densities of the primary vectors of RVF vectors, especially *Aedes macintoshi*, *Aedes ochraceous* and *Aedes tricholabis* are significantly higher than those observed during the inactive phase of irrigation ($p \geq 0.001$). A similar pattern applies to secondary vectors (*Culex* spp.), given that the densities of these mosquitoes are higher during the active irrigation phase than during the dormancy phase (Figure 2).

Plate 4: Illustration of a series of activities involved in mosquito sampling commencing with the deployment of CDC miniature light traps in residential areas (photo 1), sorting of mosquitoes (photo 2) and identification and pooling (photo 3) (photos from Rosemary Sang)

Three other important observations were made from these surveys: (i) the densities of the primary RVF vectors are significantly higher in irrigation fields than in the residential areas; (ii) the proportion of the primary RVF vectors in Murukani village, one of the non-irrigated areas, is higher during active irrigation phase compared to non-irrigation phase –factors associated with this particular observation are yet to be confirmed; (iii) no adults or larvae were trapped or collected in Sangailu, the control site in Ijara, during the period, suggesting that mosquito population densities were much lower than the minimum threshold that can be sampled. Results from this site are therefore not included in the analysis.
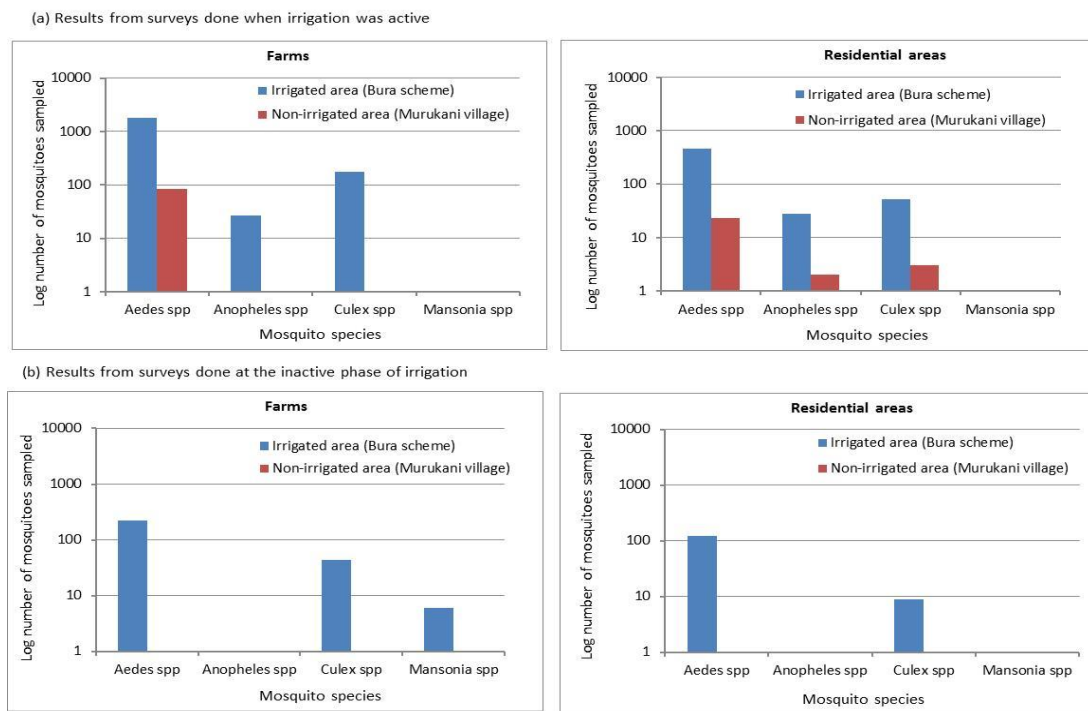

Figure 2: Comparison of the number of mosquitoes sampled in residential areas and farms in irrigated (Bura scheme) and non-irrigated (Murukani village) areas during the dry season sampling. Results from Sangailu are not included in the analysis since no mosquitoes were sampled during this period

Results from larvae sampling indicate that unit drains support the breeding of the primary vectors of RVF with *Aedes mcintoshi* being the most frequently sampled mosquito species in these drainages (Table 1). It has also been observed that *Culex univittatus* utilise unit drains, unit feeders and block feeders for breeding. This

mosquito species is an important vector of West Nile and other arboviruses associated with febrile illnesses in humans.

Table 1: Types and number of mosquitoes reared from larvae collected from various irrigation canals in Bura irrigation scheme

Sampling site/Village	Breeding habitat	Species	Number of mosquitoes identified
National Irrigation Board[1]	Unit drain	*Aedes mcintoshi*	55
National Irrigation Board[1]	Unit feeder	*Aedes mcintoshi*	105
Village 1	Unit feeder	*Culex univittatus*	5
Village 1	Unit feeder	*Culex pipiens*	8
Village 1	Unit feeder	*Anopheles gambiae*	4
Village 1	Unit feeder	*Culex vansomereni*	8
Village 2	Unit drain	*Culex univittatus*	31
Village 2	Unit drain	*Uranotaenia* spp.	9
Village 7	Block feeder	*Culex univittatus*	58
Village 7	Block feeder	*Culex pipiens*	1
Total			284

[1]National irrigation board demonstration fields

Irrigation has a favourable influence on the development of primary and secondary vectors of RVF and other arboviruses. It also appears that vectors from irrigated areas spill-over to adjacent non-irrigated farms based on the observations made at Murukani village. More surveys are being done, including those for the wet season, to corroborate these observations.

- *Rosemary Sang and Joel Lutomiah, Kenya Medical Research Institute*

Surveys on rodents suggest that irrigation schemes have higher densities of rats than non-irrigated areas

Participatory rural appraisals conducted at the beginning of the study indicated that rodent infestation in irrigated farms had risen over time and interventions that were being used to manage their population densities were not effective. We subsequently commenced surveys to trap them so as to determine whether they harbour zoonotic agents since they have been associated with RVF, *Leptospira* spp. and other pathogens. This work is being done in collaboration with the Mammology department of the National Museums of Kenya who have the mandate of trapping, collecting and curating wild animals.

Trapping started in the month of November 2013 in Tana River (Bura and Hola) followed by IJara/Sangailu in December 2013. The wet season trapping took place in March 2013. Trap sites used include:
(i) shrubby/forested habitats in irrigated and non-irrigated areas, (ii) residential areas including placement of the traps inside peoples' houses. All the mammals caught were euthanised, dissected and organs sampled. The organs sampled included liver, heart, kidney, spleen, caecum, testis, epididymis, lungs. Blood and urine were also collected when possible. These samples are being processed for laboratory analysis using metagenomic techniques. Rats were trapped, measured and dissected as illustrated in Plate 5.

Until now, a total of 123 rats have been sampled across the study sites. Eighty two of these (66.7%; 57.6 – 74.9%) were trapped in Bura and Hola irrigation schemes while 41 (33.3%; 25.0 – 42.3%) were trapped in Ijara and Sangailu. The numbers of rats trapped in irrigated areas are significantly more than those from non-irrigated areas yet uniform trapping efforts were applied in all the sites. At the same time, a range of wildlife species have been observed in non-irrigated areas, including giraffes, wild dogs, several hartebeests,

migratory birds, etc. Participatory surveys conducted in irrigated areas suggest that large mammals such as elephants were poached.

Plate 5: Setting a rat trap (1), measuring body length (2) and processing of the samples (3) (photo 1 from Johanna Lindahl, photos 2 and 3 from Enoch Ontiri)

- *Enoch Ontiri, ILRI*

Data collection systems used

We strived at ensuring proper and efficient data capture and recording at the field level. The Open Data Kit (ODK) suite of tools was heavily used to collect animal and human samples metadata and administer cross sectional questionnaires. ODK is a free and open source suite of tools that are designed and optimised for field based data collection and runs on mobile devices with an Android OS. ODK is primarily compromised of ODK Collect ,the field data collection system, and ODK Aggregate, as the backend data management system.

In addition we designed and developed a web-based system for collecting samples from patients visiting the hospitals in the four sites. This is a simple system running on a netbook that allows clinicians to collect the patients' metadata which would form part of the samples metadata.

All the samples were collected, processed and packed in the field ready for either analysis or storage in ILRI or KEMRI. We used ukasimu, an in house developed aliquoting system, that the field technicians used to record the samples and their aliquots and helped in the traceability of the samples and their associated metadata.

The different software and tools used enabled us to achieve a paperless, accurate and efficient data collection system that ensures that the samples collected have the correct and accurate metadata and can be traced back to their origin. In addition, the systems ensured that data is readily available for analysis as soon as it is uploaded to the server from the field, thereby reducing the turnaround time from data collection to writing reports and presenting findings of the research for scientists and researchers involved.

- *Absolomon Kihara, ILRI*

-

Ecological niche modeling for RVF

RVF occurrence data have been analysed using Genetic Algorithm for Rule-set Prediction (GARP) model to determine the potential distribution of RVF risk and determine predictors for the disease at the national level. RVF occurrence data were obtained by geo-referencing areas that were affected by the recent outbreak in 2006/2007. Input data that were used as independent variables included:
   (i)   Land cover data (Global Land Cover, 2000)
   (ii)   Digit elevation, with a resolution of 30m
   (iii)   Soil types at 1 km from FAO Harmonized

(iv)   Precipitation at 25 km resolution from Tropical Rainfall Measuring Mission

(v)   Temperature at 1km from MODIS

(vi)   Vegetation index at 250m from MODIS

Figure 3 gives the output of this analysis. The model gave a good fit to the data with the area under the curve (AUC) of 0.82. In decreasing order accuracy, variables that had good predictive effect include: (i) vegetation index, (ii) precipitation, (iii) elevation, (iv) land cover, (v) soil, and (vi) temperature.
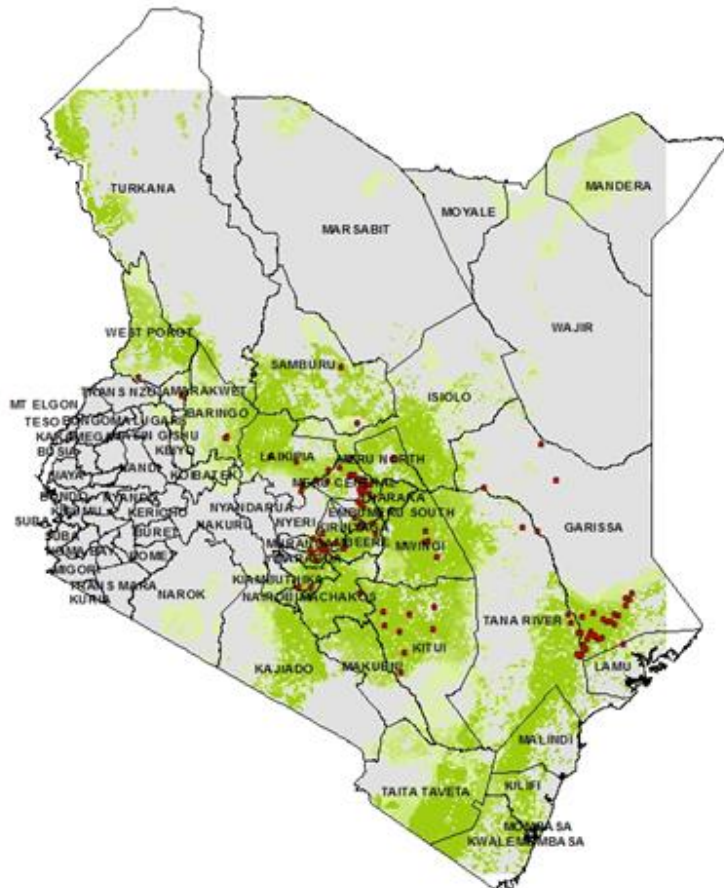

Figure 3: Output from niche modelling using GARP model. RVF risk is predicted to be high in areas shaded green, the higher the intensity of the colour, the higher the risk. Red spots are waypoints from areas that had RVF outbreaks in 2006/2007

- *Purity Kiunga, College of Agriculture and Veterinary Sciences, University of Nairobi*

Meeting reports

2 - 6 December 2013 – Bernard Bett, Sally Bukachi, Joan Karanja, Peter Lokamar, Damaris Mwololo, John Muriuki conduct a training workshop in Garissa Kenya involving clinical officers and laboratory technicians to discuss human sampling, ethical considerations and questionnaire surveys

17 – 21 March 2014 – Bernard Bett and Fred Tom Otieno participate in a GIS training course co-facilitated by the Zoonosis Disease Unit and ILRI

26 March 2014 – Bernard and Salome Bukachi meet with Professor Isaac Nyamongo a co-PI of the project *Early Warning Systems for Improved Human Health and Resilience to Climate – Sensitive Vector-borne Diseases in*

Kenya funded by TDR/WHO to explore areas of collaboration. A Memorandum of Understanding for this collaboration is being developed.

1 April 2014 – Bernard attends USAID Climate Change Technical Officers Meeting at Windsor Golf Hotel, Nairobi, April 1, 2014 and gave a presentation entitled Climate change impacts on animal health and vector borne diseases

Activities planned for the next quarter

- Complete the screening of serum and blood samples from livestock and people
- Commence the screening of samples from rats
- Finalize blood sampling in the health centers
- Commence laboratory analysis of mosquito samples that have been collected and carry out repeat entomological surveys
- Finalize ecological analyses
- The project team to convene a write shop in Limuru to commence development of project publications in the last week of May 2014

Partners

Salome Bukachi Institute of Anthropology, Gender and African Studies, University of Nairobi, and

John Muriuki, Damaris Mwololo and Purity Kiunga, College of Agriculture and Veterinary Sciences, University of Nairobi

Ian Njeru and Joan Karanja Disease Surveillance and Response, Ministry of Health, and

Salome Wanyoike Department of Veterinary Services, Ministry of Agriculture, Livestock and Fisheries

Rosemary Sang and Joel Lutomiah, Kenya Medical Research Institute

Mohamed Said, Enoch Ontiri, Johanna Lindahl, Shem Kifugo, Fredrick Tom Otieno, Deborah Mbotha and Bernard Bett International Livestock Research Institute