Perspectives of predictive epidemiology and early warning systems for Rift Valley fever in Garissa, Kenya

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Etiology, Epidemiolgy and Economics of RVF

- RVF viral zoonosis of cyclic occurrence(5-10yrs), Described In Kenya in 1912 isolated in 1931 in sheep with hepatic necrosis and fatal abortions.

- Caused by a *Phlebovirus* virus in *Bunyaviridae(Family)* and transmitted by mosquitoes: *Aedes, culicine* spp.

- The RVFV genome contains tripartite RNA segments designated large (L), medium (M), and small (S) contained in a spherical (80–120 nm in diameter) lipid bilayer

- Major epidemics have occurred throughout Africa and recently Arabian Peninsula; in Egypt (1977), Kenya (1997–1998, 2006-2007), Saudi Arabia (2000–2001) and Yemen (2000–2001), Sudan (2007) and Mauritania (2010).

- Epidemics marked with unexplained abortions (100%) Cattle, camels, small ruminants, potential human epizootics(mild)

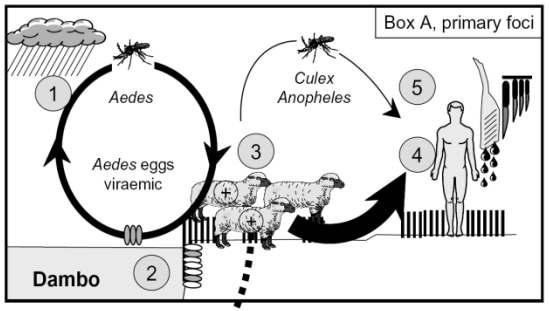
- Economic losses in Garissa and Ijara districts (2007) due to livestock mortality was Ksh 610 million, in 3.4 DALYs per 1000 people and household costs of about Ksh 10,000

Montgomery , 1912, Daubney 1931, Davies 1975, Jost *et al.*, 2010

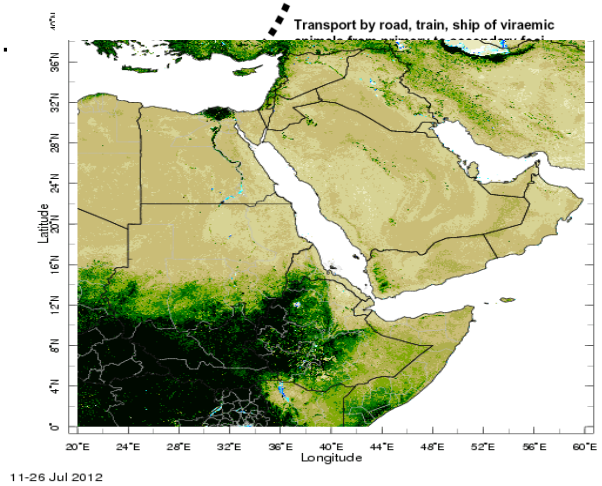
Risk Factors (Ecological and Climatic)

- Precipitation: ENSO/Elnino above average rainfall leading hydrographical modifications/flooding (“*dambos*”,dams, irrigation channels).

- Hydrological Vector emergency: 35/38 spp. (interepidemic transovarial maintenance by *aedes 1º* and *culicine 2º*,(🕷 🕷 vectorial capacity/ competency)



- Dense vegetation cover =Persisten NDVI.(0.1 units > 3 months)

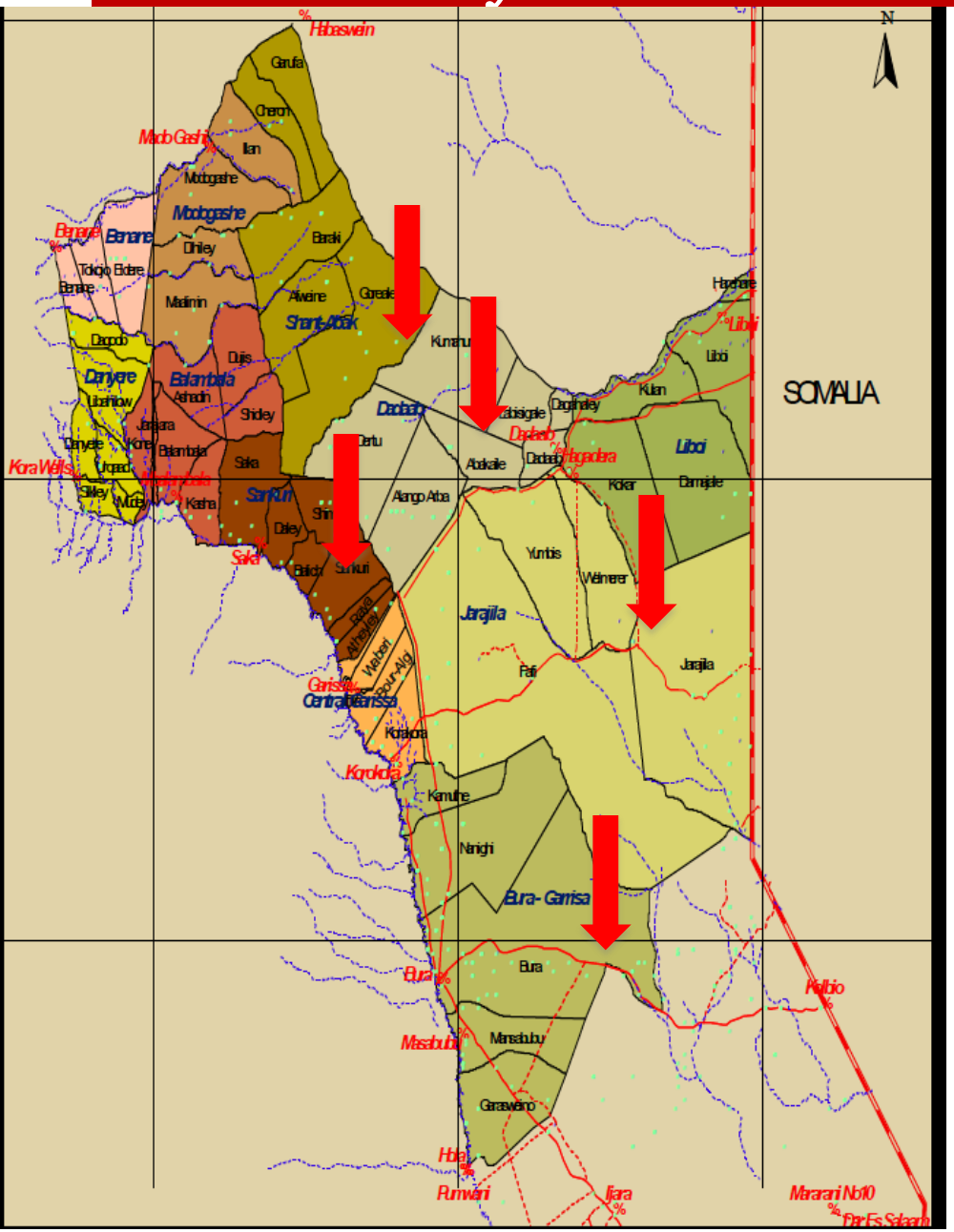


- Soil types: Solonetz, Solanchaks, planosols (drainage/moisture)

- Elevation : altitude <1,100m asl

Linthicum *et al*., 1999; Anyamba *et al*., 2009; Hightower *et al*., 2012; Bett *et al*.,2012

Study sites: Garissa RVF Hotspots



CRITERIA

- Historical outbreaks in (2006-2007)
- Shantabaq, Yumbis, Sankuri ,Ijara, Bura, jarajilla, Denyere
- Large ruminant populations
- Transboundary livestock trade
- Transhumance corridors
- Animal clustering at water bodies
- Riverine and savannah ecosysytems(vector contact rates)
- Sentinel herd surveillance(shanta abaq and Ijaara).

Current Research Methods : RVF Spatiotemporal Epidemiology

- Participatory Epidemiology: Rural appraisal and Community EWS to RVF investigated.
- Sero-monitoring of sentinel herds and Geographical risk mapping of RVF hotspots?
- Trans-boundary Surveillance for secondary foci.
- Disease burden analysis and predictive modeling???
- Decision support tools for community utilization(Risk maps, brochures, radio…)


Shanta abaq


Daadab


Shimbirye

RVF Participatory Community Sensitization

- Triangulation, Key informant interviews and Focus Group discussions on RVF and Climate Change.

- Disease surveillance Committees (Animal health workers ,Pastoralists , Veterinary and Public health officers)

- Community mapping of watering Points/Dams or “Dambos”.

- Socioeconomic analysis of disease impacts

- Livelihood analysis impacted by RVF

- Capacity building workshop on climate change resilience and RVF control mechanisms

- Information feedback mechanisms
(Schools, Churches, village meetings)

Garissa: Process based RVF Outbreak Predicitve Modelling

EPIDEMIOLOGICAL DATA

OUTCOMES: SEROLOGICAL DATA (case definition)

PCR/ELISA(IgM, IgG)
Morbidity, Mortality,

TEMPORAL DATA
Time Series

Rainfall, Temperature, NDVI

GEOGRAPHIC/SPATIAL DATA
Remote Sensing/GIS

NDVI, Soil, Elevation

Spatial correlation

SOCIOECONOMIC DATA
Participatory

Interventional costs, Demographics, Income, Assets,

CORRELATIONAL ANALYSIS

PREDICTIVE MODELLING
LOGISTIC REGRESSION, GLM

VECTOR PROFILE

$$P_{RVF}^{div} = P_{rainfall} + P_{temp} + P_{NDVI} + P_{soil} + P_{elev}$$

Surrogate(Proxy)Predictors(variables) > dropped

Predictive modeling: Logistic Regression/GLM

- **Historical RVF data (1999-2010)***
- **Outcome**: RVF cases were represent with 0 or 1(-ve/+ve)
  : Cases in 8 of 15 divisions (Dec 2006 –Jan 2007 outbreak)
- **Predictors**: Rainfall, NDVI, Elevation
- **Data used**: 1999 – 2010: 2160 observations
- Univariable analysis done in **R statistical computing** environment
- model <- glm(case ~ predictor, data, family="binomial")- 6 models

Univariable Model

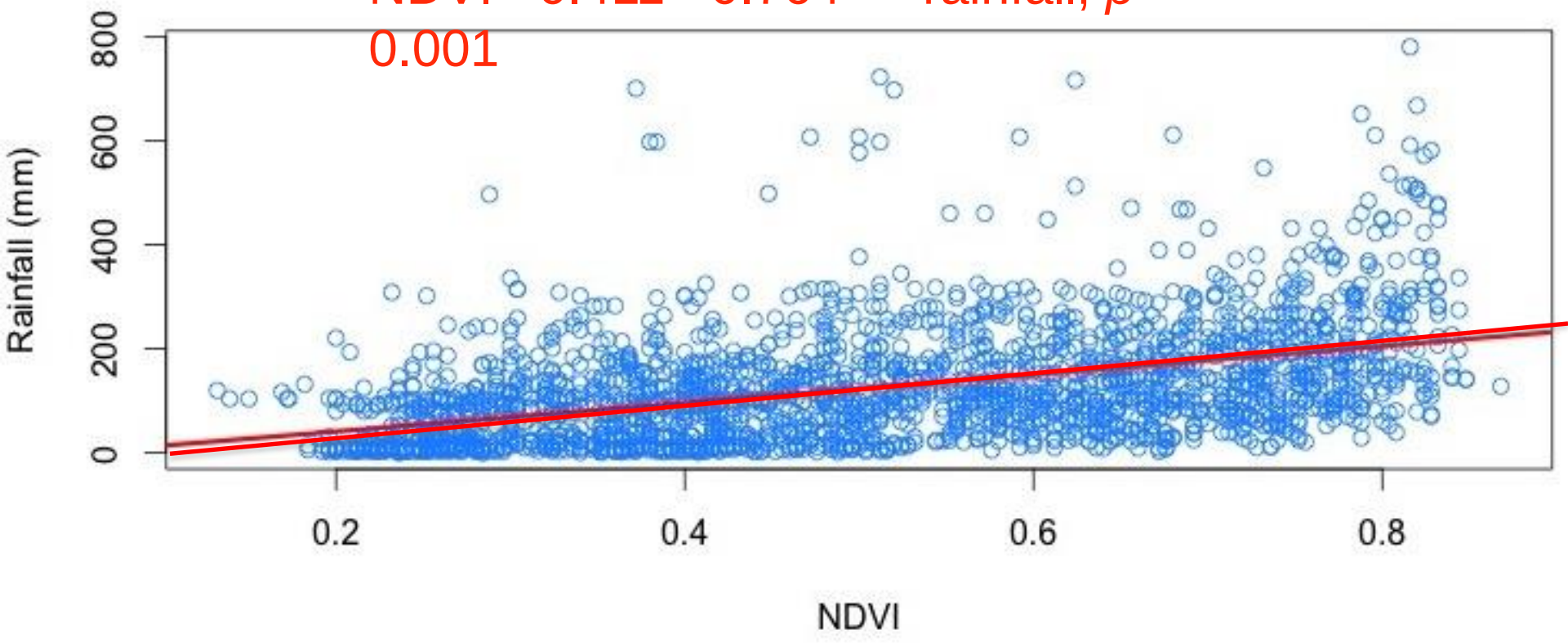
Variable	Odds Ratio(OR)	Lower 95% CI	Upper 95% CI	*p*-value
NDVI	1.9	1.40	2.9	< 0.001
Rainfall	1.08	1.05	1.11	< 0.001
Elevation	1.01	0.99	1.01	0.695

Multivariable Model

Variable	Odds Ratio(OR)	Lower 95% CI	Upper 95% CI	*p*-value
NDVI	1.47	1.05	2.2	0.03
Rainfall	1.06	1.03	1.09	< 0.001

Correlation Analysis: NDVI vs Rainfall

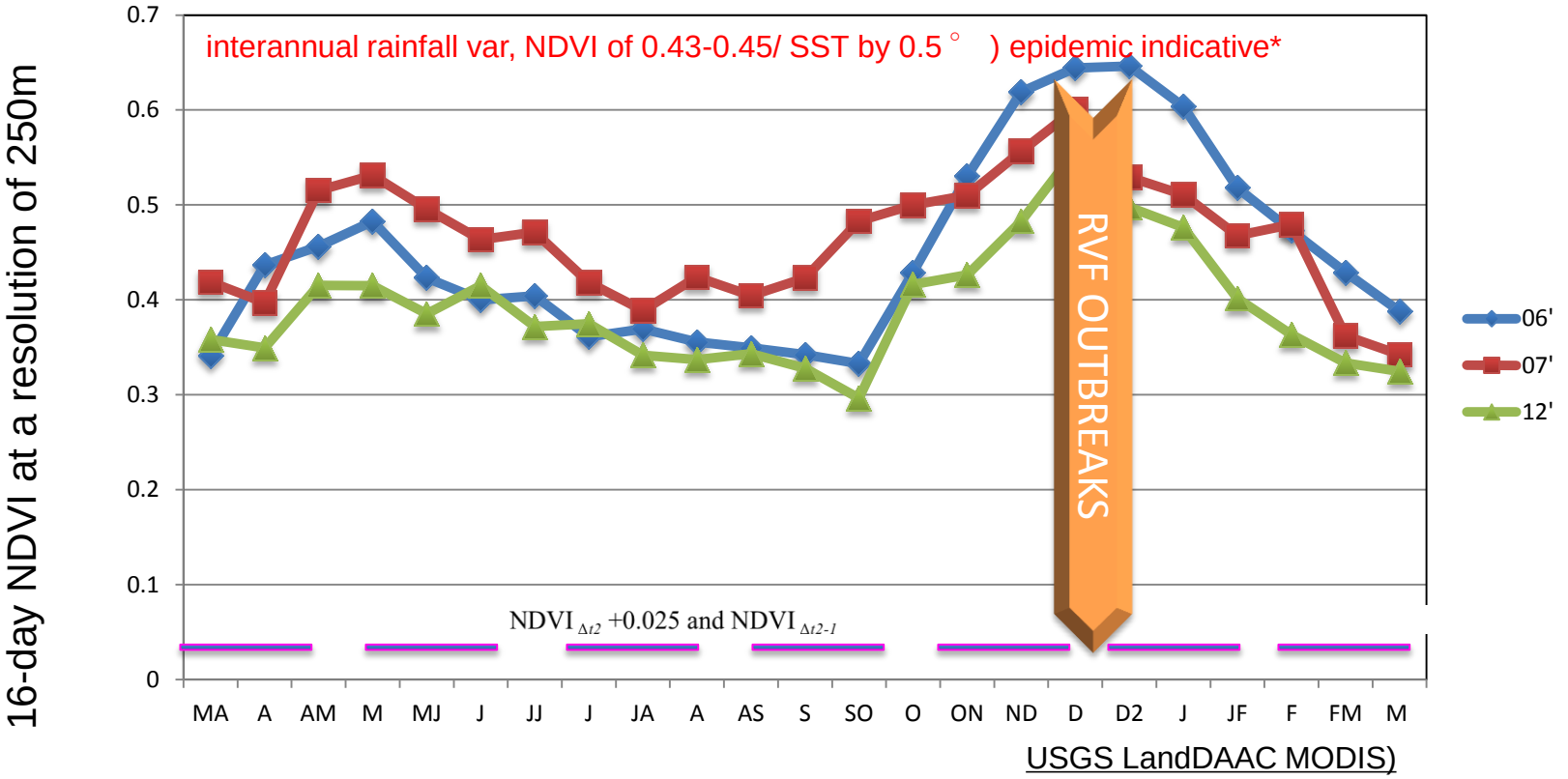
NDVI= 0.411+ 0.764 × rainfall, $p<$ 0.001



Pearson's correlation coefficient (r) = 0.458

Linear relationship between rainfall and NDVI: it is thus possible to utilize these factors to examine and predict spatially and temporally RVF epidemics.

Garissa: Multi year NDVI Comparison(2006/2007/2012)

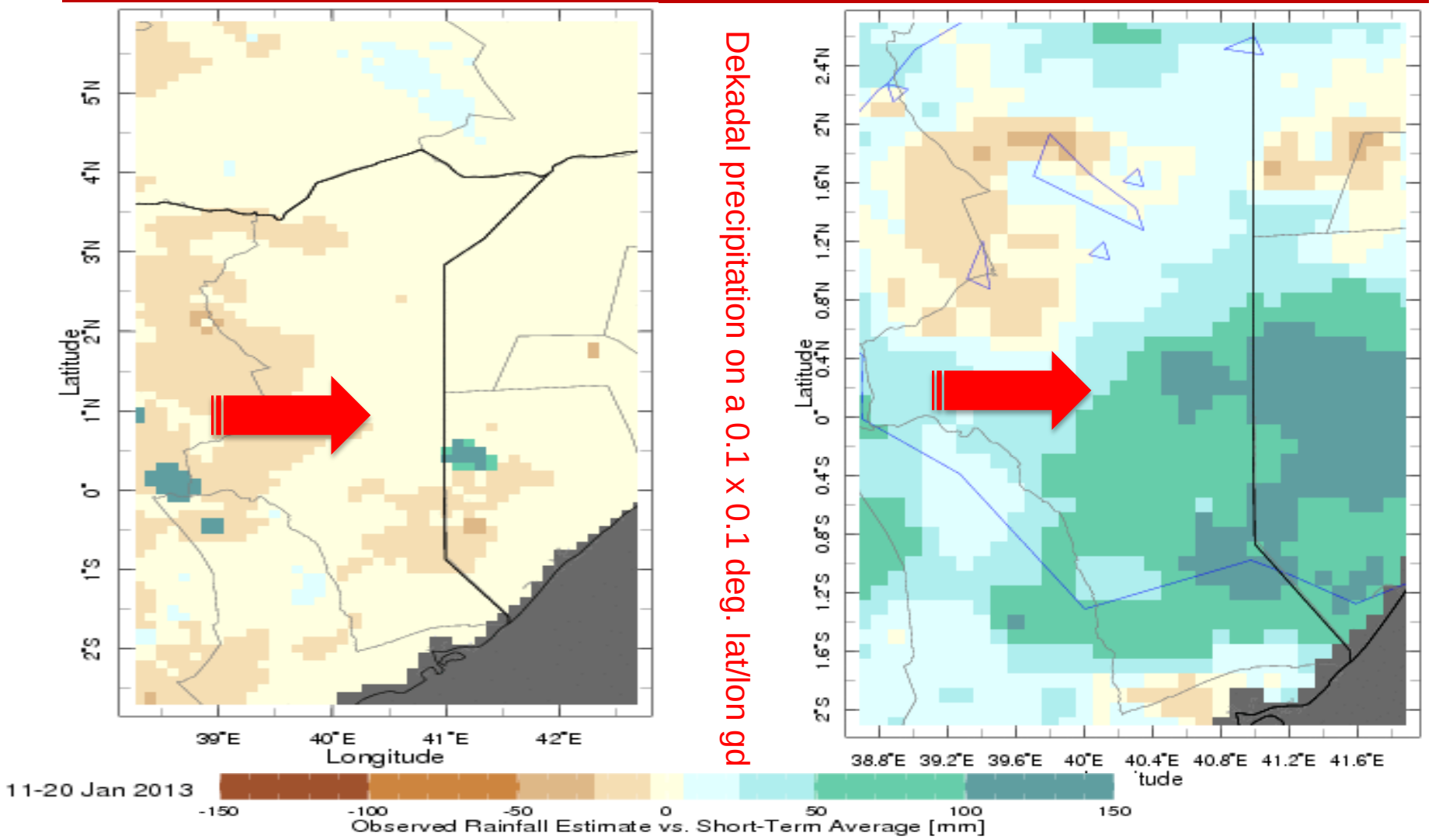


- Persistence in positive NDVI anomalies (average greater than 0.1 NDVI units) for 3 months would create the ecological conditions necessary for large scale mosquito vector breeding and subsequent transmission of RVF virus to domestic animals and humans.

- Climatic seasonal calendar concurrence with KMD (OND) short rains and RVF alerts issued by DVS.

** Linthicum et al ., 1999*

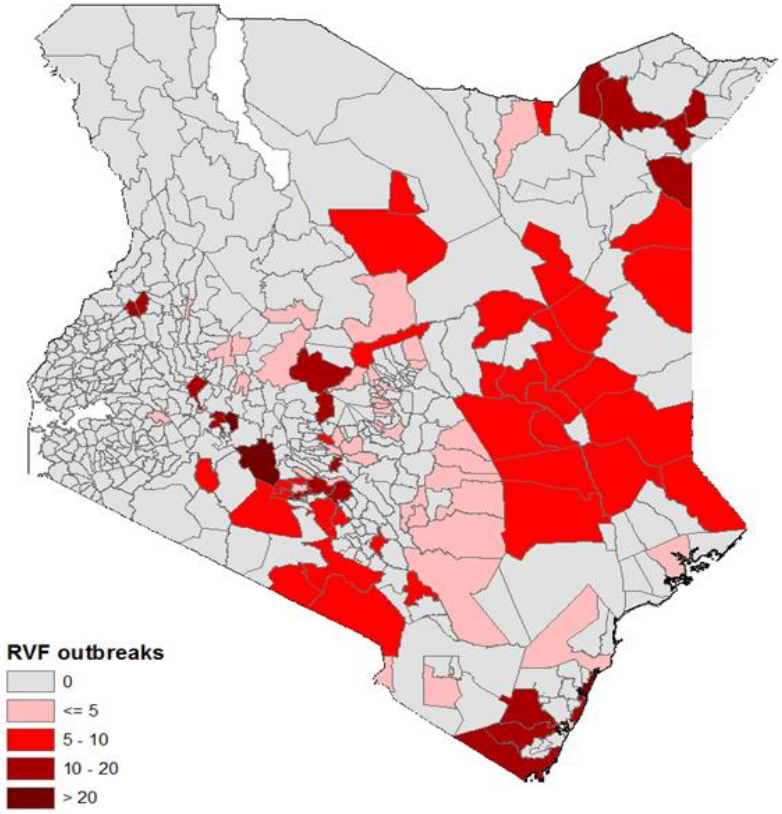
Garissa: Rainfall Estimate Differences Jan-April 2013

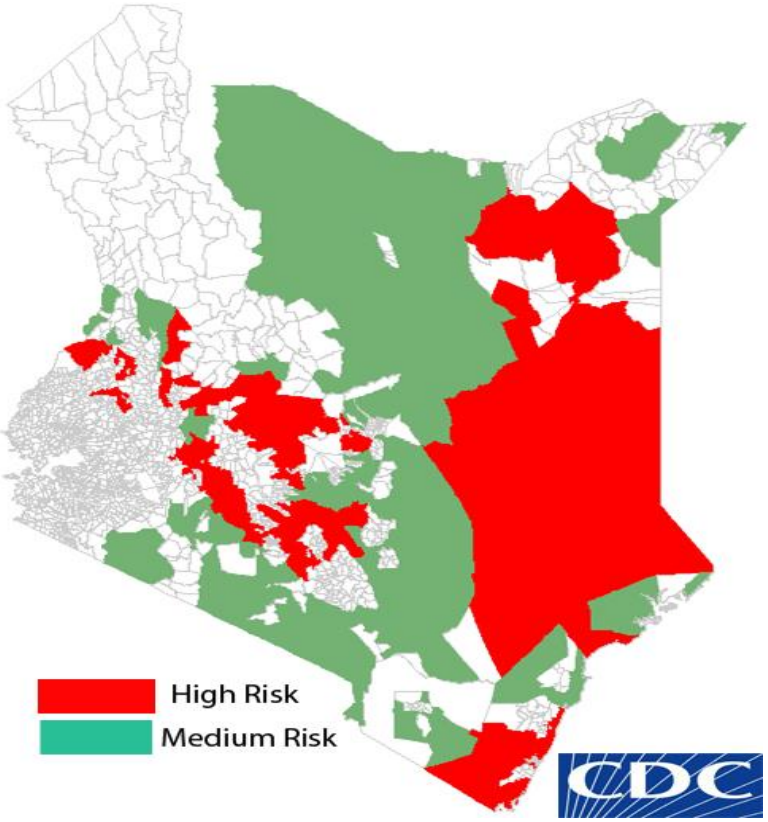


The short-term average may provide insight into changes in RVF risk in areas where precipitation anomalies are the principal cause of RVF epidemics by increase vector competence.

CPC/FEWS RFE2.0*

Ongoing Research: RVF Outbreaks and Risk correlation

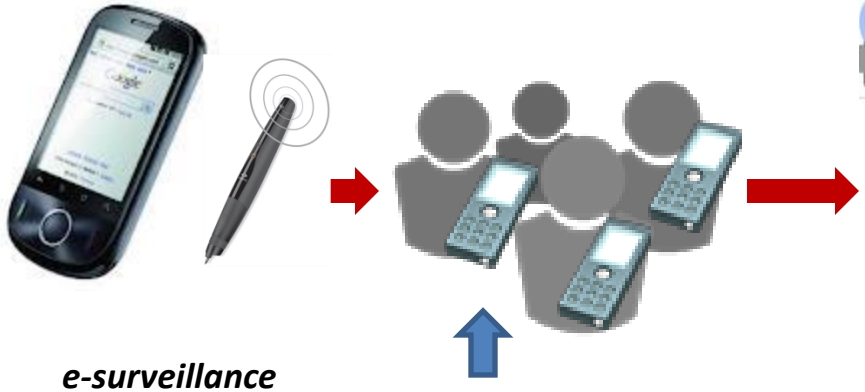




- Response can be geographically targeted (Disease Information Systems).
- Vaccine allocation and distribution should be site specific(cost saving mechanism)
- Vector surveillance for secondary foci in peri-urban locations (Vectorial competence).

Bett *et al.*,2012

RVF Monitoring and Surveillance –Community Model

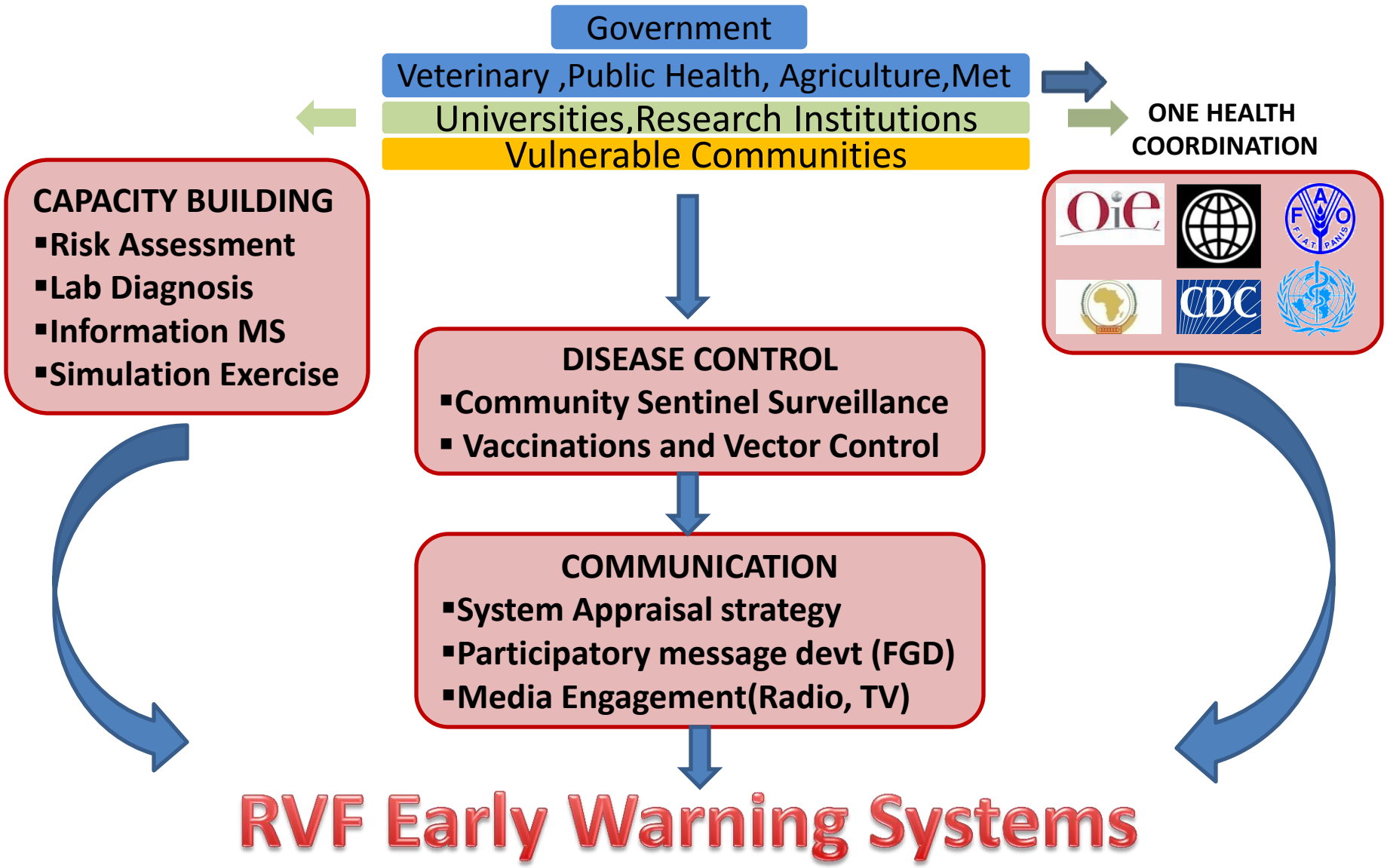


e-surveillance

Aanansen *et al*., 2009, Madder *et al*., 2012

- *e-surveillance* and data gathering by (Mobile phones, PDA)
- Community sensitization/awareness by Syndromic surveillance
- Dissemination of Information through community vernacular radio,SMS

RVF: Decision making Collaborative tools



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Study Participants

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- Communities: Shanta abaq,Sankuri,Daadab,Ijara,Shimbirye