Risk Modelling and Forecasting Tools for Enhanced Early Warning: "The Example of Rift Valley Fever"

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1. Background

FAO Animal Health Service (AGAH) mandate:

- Prevent, contain and control the world’s most serious livestock diseases at their source, while also surveying for newly emerging pathogens in a changing environment

Core activities (EMPRES/GLEWS):

- *Early warning* and *early detection* to enhance early action and response
1. Background – what is needed

- Early Warning Systems (EWS) to provide information on occurring animal health hazards that might evolve into disasters unless early response is undertaken.

- EWS should be based on indicators that can be easily monitored to detect risk conditions

- Indicators should be specific (tend not to occur when outbreaks aren't seen)

- Cost effective
1. Rift Valley fever (RVF)

- Major zoonotic viral vector-borne disease
- Cattle, sheep, goats, camels, wildlife and humans
- Transmitted by mosquitoes species (e.g., *Aedes, Culex*), but also through the contact with infected animals
- Transovarial transmission in *Aedes*
- Spill-over from wild animals
- Driven by climate variability
1. RVF distribution and main hotspots

- 2012 and 2015 - 2018: abnormal weather conditions across western and eastern Africa leading to increased risk and RVF outbreaks

- Growing concern of geographical spread (Middle East and European Union countries)
1. RVF climatic risk factors

**Influence viral activity & vector abundance:**

- Heavy rains, floods, dry spells
  (+) Hatching mosquito eggs

- High temperature
  (+) feeding frequency
  (+) egg production
  (-) duration of development cycle

→ Allows forecasting outbreaks
1. RVF vector ecology, epidemiology

East Africa - Flooding areas (e.g., dambos, Kenya)

West Africa - Temporary ponds and dry spells (e.g., Senegal)

We captured this regional variation in rainfall patterns to predict vector(s) dynamics and RVF at-risk areas in East and West Africa.

Source: FAO 2012

Source: Vignolles et al 2011
2. Environmental Monitoring using Remote Sensing

- Earth observation
- Massive data collected
- Long time-series
- Near real-time environmental data (climate, vegetation, T, soil, etc.)
- Data increasingly available free of charge
- Cost-effective
- Real-time Early Warning Systems
- Real-time risk modelling & forecasting
- Ground truth
2. Environmental Monitoring in Animal Health

Why is the EM applied in animal health?

“EM of disease drivers helps to stay at the left side of the epi curve”

Source: Changing Disease Landscape (World of Livestock 2013; FAO)
2. Environmental Monitoring for RVF

- Viral amplification
- Culex spp
- Rostal et al

- Number of cases
- Days

- Subclinical wild and domestic animal cases
- Domestic animal outbreak
- Human outbreak

- Sylvatic cycle

- Aedes spp

- Viral amplification

- Human outbreak

- Rostal et al
3. FAO RVF Early Warning (EW) System

Developed by NASA, FAO, WHO and OIE is based on:

- Climatic (rainfall, ENSO, SST) & vegetation (NDVI) anomalies (Anyamba et al. 2009)
- Retrospective analysis for model calibration/validation:
  - Field observations and outbreaks evaluations
  - Different RVF modeling approaches
- EW messages
3. FAO RVF Early Warning System

3 main components:

- Climate-based model (Anyamba et al. 2009)
- ENSO (El Nino Southern Oscillation) current state and forecast
- Current and forecast regional rainfall maps

Risk map & Risk Assessment every month

- ENSO: **low** probability of warm-event
- Rainfall forecast: **low** probability of heavy rainfall
- NDVI anomalies in Jan-Feb 2014: **limited** areas
3. RVF alerts - early warning messages

- Numerous alerts to the countries at risk (joint RA with NASA, WHO, OIE field)

- In the past 3 years:
  - West Africa (2016 and 2017)
  - Southern Africa (2018)

- RVF forecasts in quarterly FAO bulletins (FCC and EWEA)
3. RVF Early Warning Tool (FAO prototype)
Claudia Pittiglio - Focal Point

Near-real time monitoring and risk mapping of RVF vector amplification with GEE

Transition from a desktop to a cloud-based platform
3. Google Earth Engine and dry spells

![Google Earth Engine screen with a map showing dry spell areas in Mali and Senegal.](image)
4. West Africa alert
July-Sept 2017

- Joint FAO-NASA RA

Jan 2018:
RVF human case in the Gambia
4. East Africa joint RA and first alert

Nov 2017 - Jan 2018

**Uganda**
- Joint FAO-WHO RA in early Dec 2017

**South Sudan**
- Joint FAO-WHO-OIE RA in Jan 2018
4. Southern Africa alert

Jan-Feb 2018

- Joint FAO-NASA RA in early Feb 2018

May 2018:
RVF reported in South Africa
4. East Africa second alert
Issued on April 2018

FAO Risk Assessment (April 2018)

- **High** risk of RVF vector amplification in Kenya
- **Moderate** for the rest of EA

**June 2018:**
RVF reported in Kenya
4. RVF forecast Sept-Nov 2018

**High risk** of RVF spread in the region

RVF risk maps from Dec 2017 to July 2018

IRI Precipitation forecast (SON 2018)
## 4. Strengths and Challenges of the RVF EWS

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<th>STRENGTHS</th>
<th>CHALLENGES</th>
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<td>Near real-time environmental monitoring system</td>
<td>Real-time validation of RVF at risk areas (mosquito surveillance, sentinel herds; expert knowledge, etc.)</td>
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<td>Cost-effective</td>
<td>Calibration for countries with no RVF outbreak data</td>
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<td>Availability of RVF risk maps on monthly basis</td>
<td>Establish a network of experts to discuss the RVF risk maps and update the RVF situation</td>
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<td>Accurate predictions for endemic countries with RVF historical data</td>
<td>Data sharing to assess the occurrence and spread based on effective exposure (n animals, vaccinations, animal movement, trade)</td>
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<td>Quantitative RA: Integration of other risk factors to assess and quantify animals and humans at risk</td>
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