Modelling malaria transmission dynamics in irrigated areas of Tana River County, Kenya

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Introduction

- Irrigation schemes introduced in areas of high malaria endemicity often amplify malaria burden especially if no mitigation or adaptation measures are implemented (Renshaw *et al.*, 1998)
- The development of Bura and Hola irrigation schemes in Tana River County, Kenya (to enhance food security) might have escalated the baseline risk of the disease given that the area is infested with efficient mosquito vectors (*Anopheles arabiensis*). This might be complicated further by high levels of poverty in the area (72%), literacy levels and insecurity that limit access to medical services.
- Land use changes such as irrigation affect microclimatic conditions that influence the abundance and survivorship of mosquitoes by creating standing water masses which increases humidity, hence better survivorship of mosquitoes.
- To analyse the effects of irrigation on malaria transmission risk, we use a one-vector-one host deterministic model made up of a mosquito population sub-module and disease transmission sub-module. Important assumptions of the model are:
  - Gonotrophic and sporogonic cycles of the mosquito vector are influenced by temperature. The degree-day principle described by Hoshen and Morse (2004) is used to capture the effects of temperature;
  - Water from irrigation is added to that from 10-day accumulated rainfall while determining breeding potential of a vector using the Fuzzy distribution model described by Emert *et al.*, (2011). However, to harmonize units used to measure the quantities of irrigation water with those of rainfall (mm), information on the frequency and duration of irrigation in a year, volume of water pumped/day when the irrigation is active, land area where water is channelled to and estimates of water losses are considered.
  - The Fuzzy distribution (Emert *et al.*,2011) is also used to estimate mortality rates of eggs, larvae and pupa. Difference equations are used for all the model sub-modules.

Approach

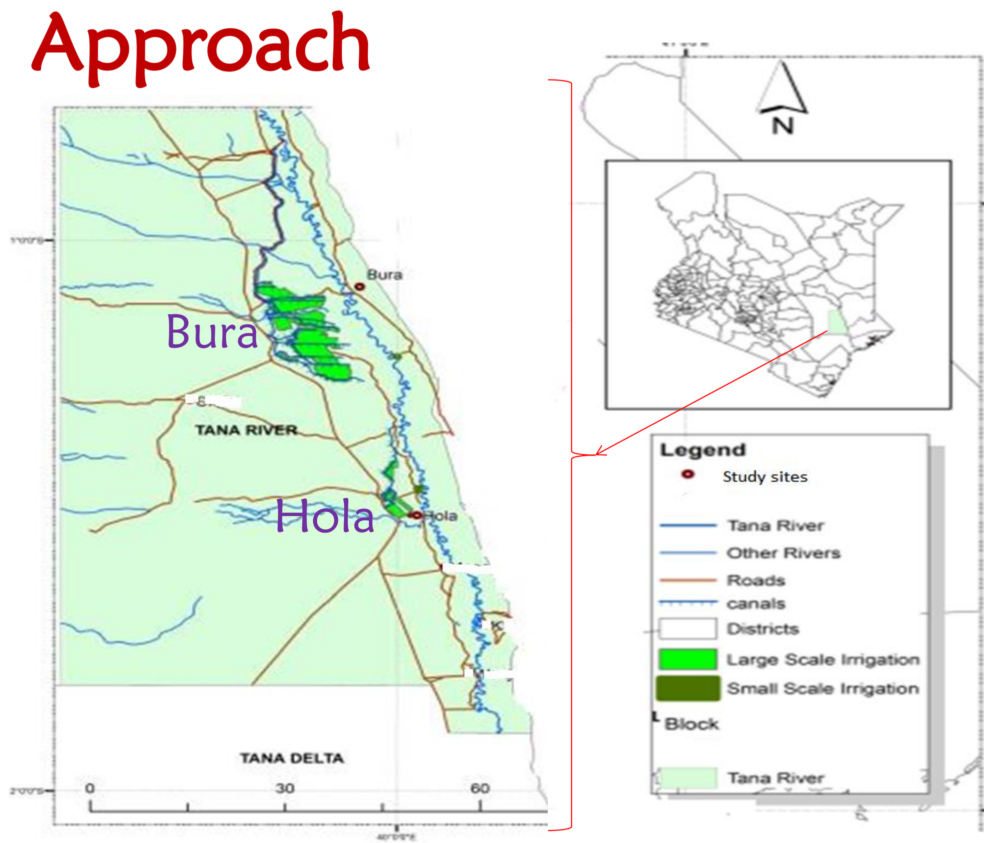

Figure.1. Map of the study area (ILRI ,2013)

Figure.2. Irrigation scheme

Data

- The locations of Bura and Hola irrigation schemes are shown in Figure 1, and Figure 2 shows a farm that is being prepared for planting.
- Model parameters were obtained from literature.
- Data on malaria prevalence for the year 2013 were obtained from the local hospitals and used for validating the model.
- Rainfall and temperature data during the year 2013 were obtained from weather station at Bura irrigation scheme.

Model development

- Figure 3 outlines the structure of the model. The model was implemented in MS Excel using difference equations.
- The Fuzzy distribution function was used to relate rainfall and irrigation patterns with oviposition and mortality rates of acquatic stages of mosquitoes.
- The model was fitted to malaria prevalence data obtained from the local hospitals by varying the parameters of the Fuzzy distribution function (Emert *et al.*, 2011). Parameter values that gave the least variance between predicted and observed prevalence were used.

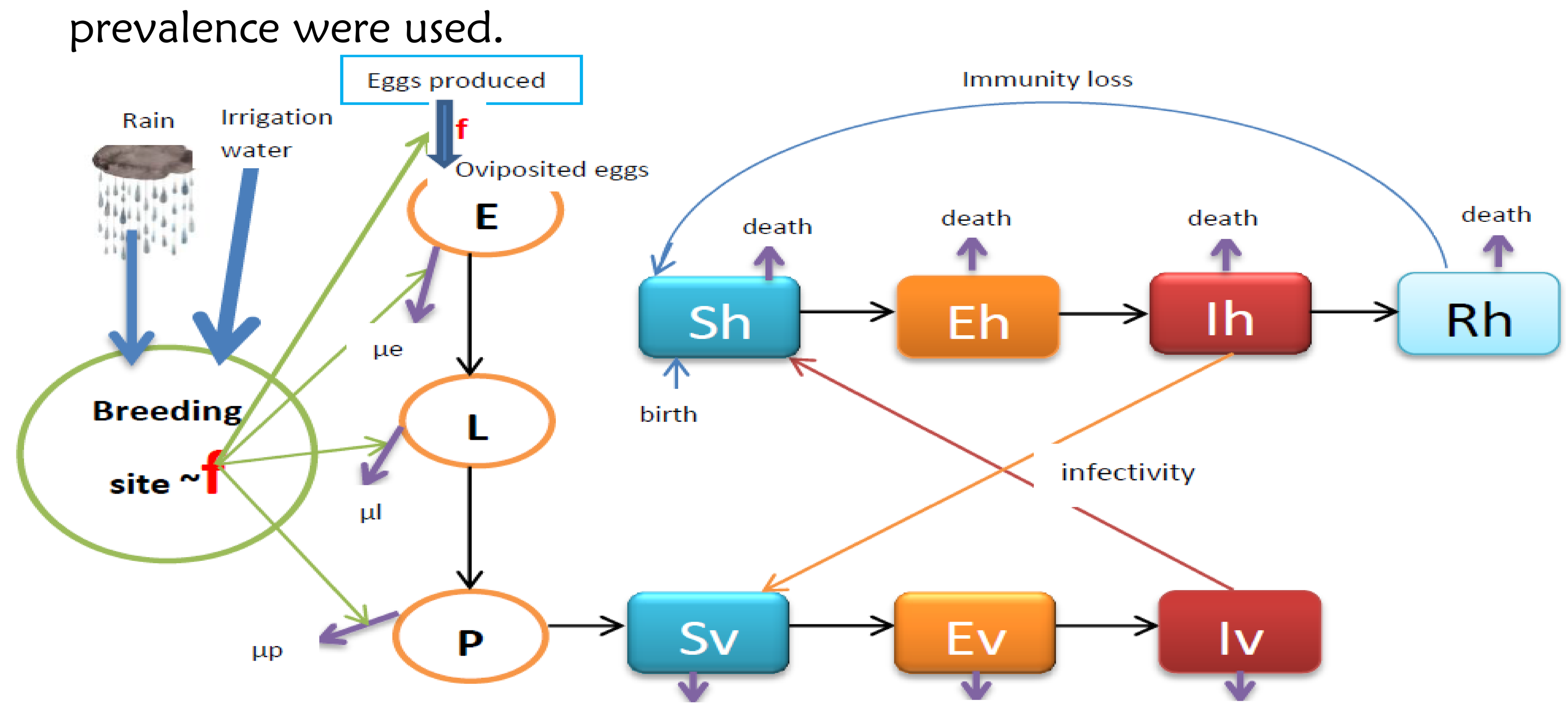

Figure 3. Model structure

Findings

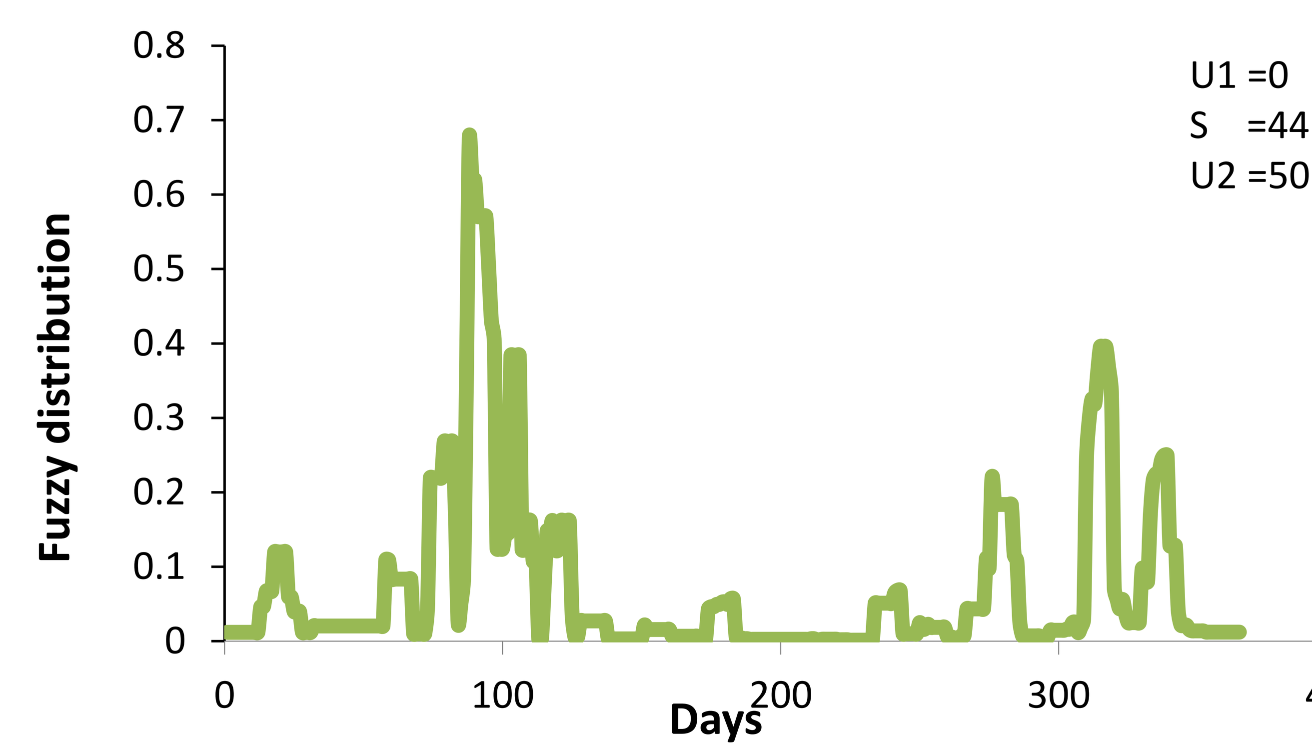

Figure 4. Fuzzy distribution model used to determine oviposition and mortality rates of acquatic stages of malaria vectors. U1=unsuitable condition (no water), S=Suitable condition and U2=Unsuitable conditions (a lot of water)

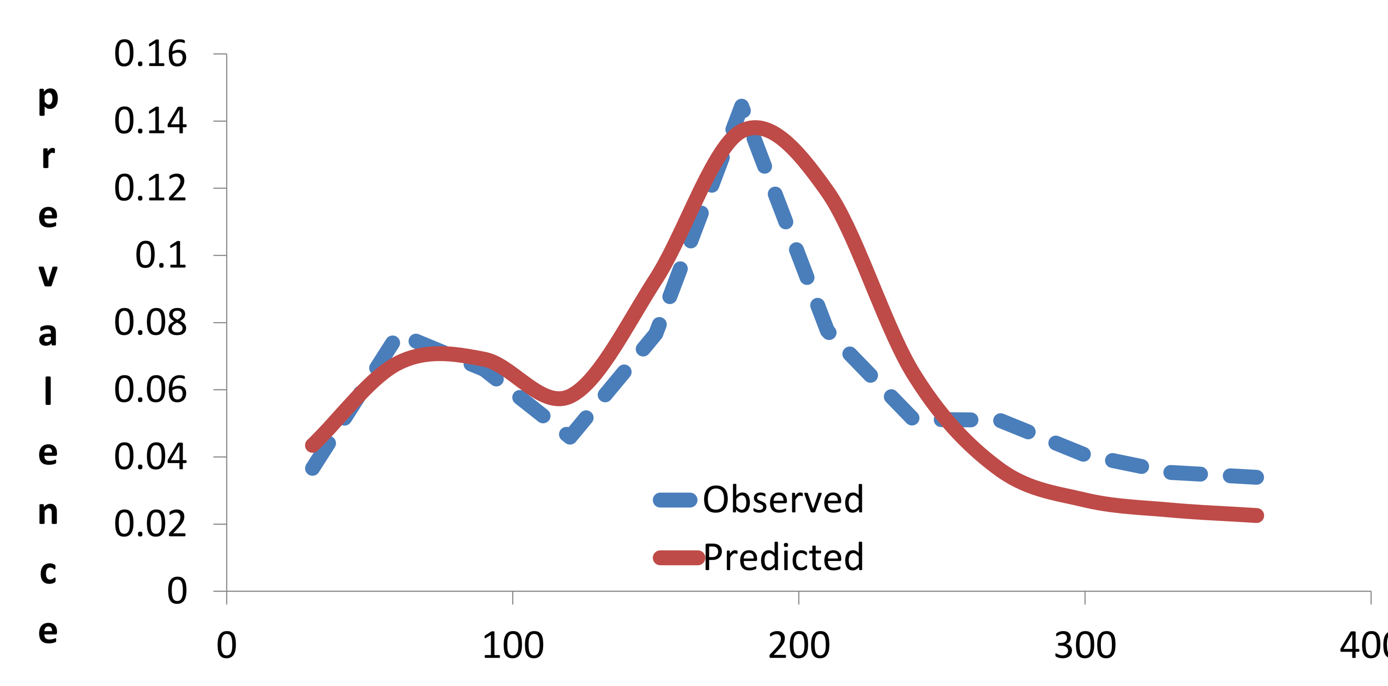

Figure 5. Predicted and observed malaria prevalence

- The model fitted the data well and predicts an upsurge in the number of malaria cases 2-3 months after the rains or irrigation. This supports findings published by Githeko and Ndekwa (2001) that suggest that malaria incidence lags onset of rains by 3-4 months.
- The model is very sensitive to changes in blood meal index and suitability conditions (of the Fuzzy distribution model) – results not shown – and further analyses are being done to validate these findings
- At the moment, it is still difficult to tease out the effects of rainfall from those of irrigation due to unavailability of data from non-irrigated areas. Further analyses will be done to address this issue.

Conclusion:

This model could be used to predict the prevalence of malaria in irrigated areas of Tana River County. This would enable decision makers implement appropriate control measures in good time.

Direction

- Data from non-irrigated areas and covering a longer period of time are being collected for more rigorous model validation.
- The impact of various interventions on malaria transmission will be analysed using a validated model.

References

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