Mechanistic modelling of the links between environment, mosquitoes and malaria transmission in the current and future climates of West Africa

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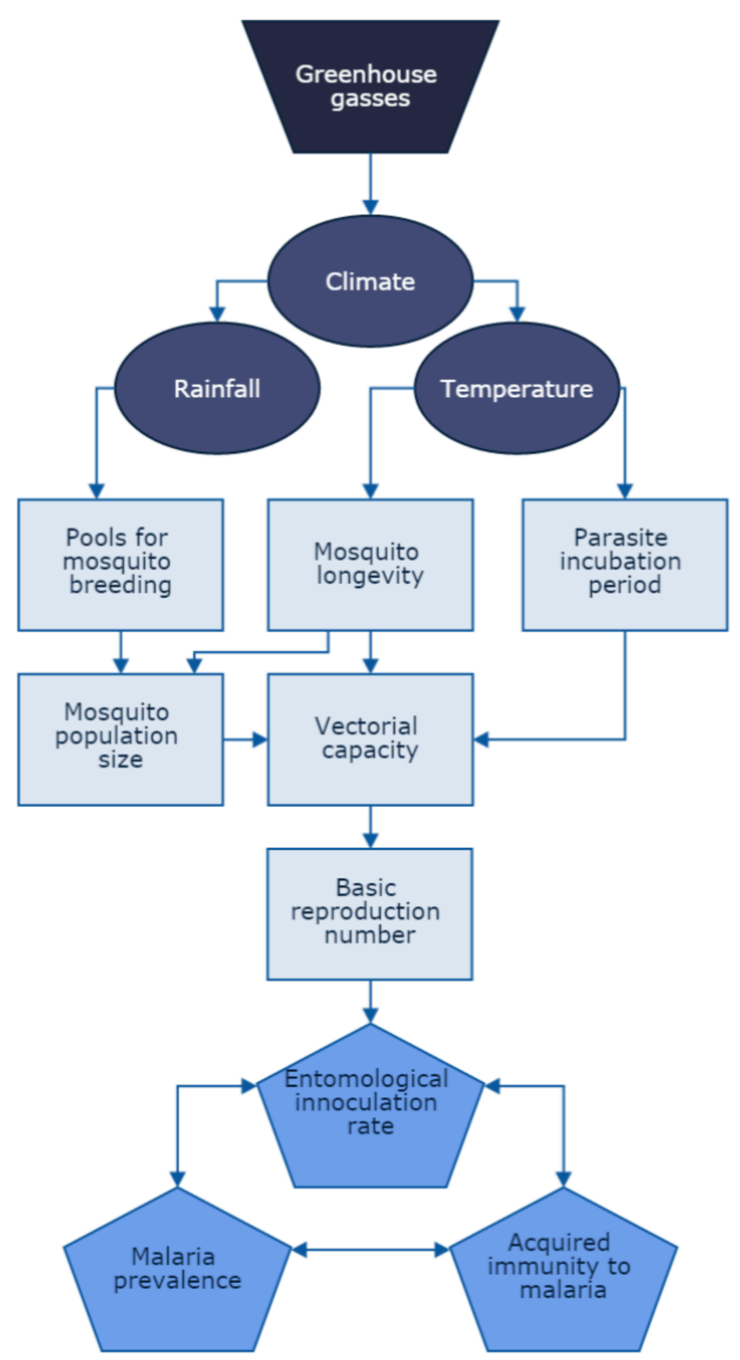
Introduction

West Africa currently has the highest rates of malaria deaths in the world. Malaria transmission in this region is closely tied to climate, as rain fed water pools provide breeding habitat for the anopheles mosquito vector, and temperature affects the mosquito's ability to spread disease.

We have been engaged in decade-long study in West Africa involving field observations and sophisticated model simulations of village scale transmission. Here, we present our framework of highly detailed, spatially explicit mechanistic modelling, and give examples of the advantages and applications of this approach..



Advantages of mechanistic modelling approach

Evaluate malaria control interventions

Interventions at all points in the malaria transmission can be represented in the model including those targeted at mosquito larvae (environmental management, larvicide), adult mosquitoes (insecticide treated bednets, indoor residual spraying), and humans (vaccination, case management).

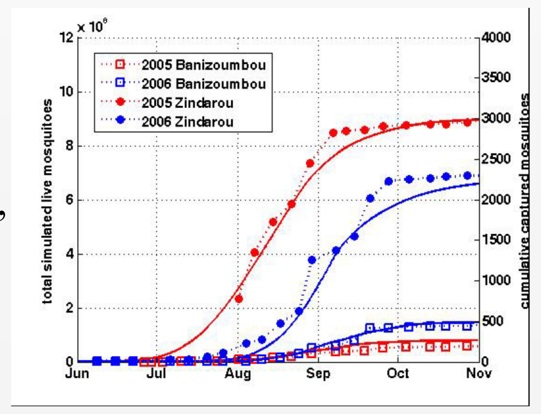
This can facilitate planning interventions by showing which interventions would be most effective for a given location, and the levels control necessary to reduce transmission

Image: WHO/S. Hollyman

Compare to observational data

Model results can be compared with observations at multiple stages in the transmission cycle to ensure accuracy. These comparisons give us confidence in our simulation results for locations or variables for which data are not available.

Hydrology: depth, temperature, and location of water pools over time; *Entomology*: larval counts, mosquito density, biting rate, entomological inoculation rate; *Epidemiology*: incidence, prevalence



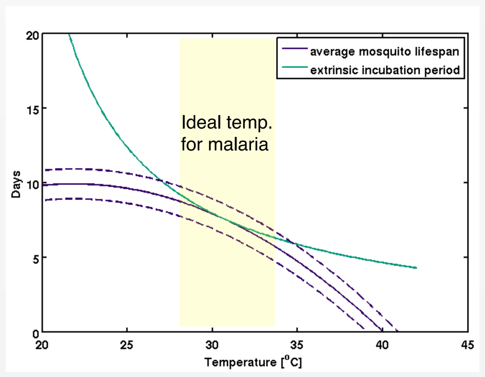
Source: Bomblies et al., 2009

Threshold effects and nonlinearities

There are many nonlinearities and threshold effects in the environment to malaria transmission pathway. This is especially true at the fringes of transmission. Acquired immunity, which is a function of previous inoculations, also plays an important role in modifying disease outcome. The mechanistic approach can resolve these effects.

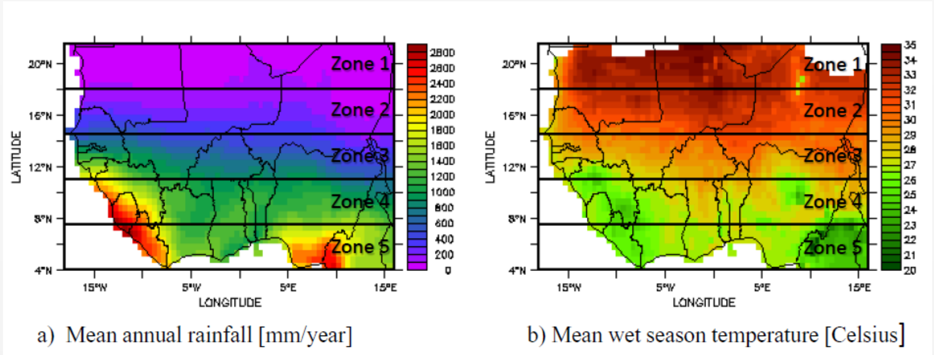
Examples:

- Water pools must last 7-10 days for larvae to develop
- Mosquito lifespan must exceed parasite incubation period (see figure on right)
- Basic reproduction number must exceed 1 for transmission
- Sustained low parasite levels can lead to local elimination



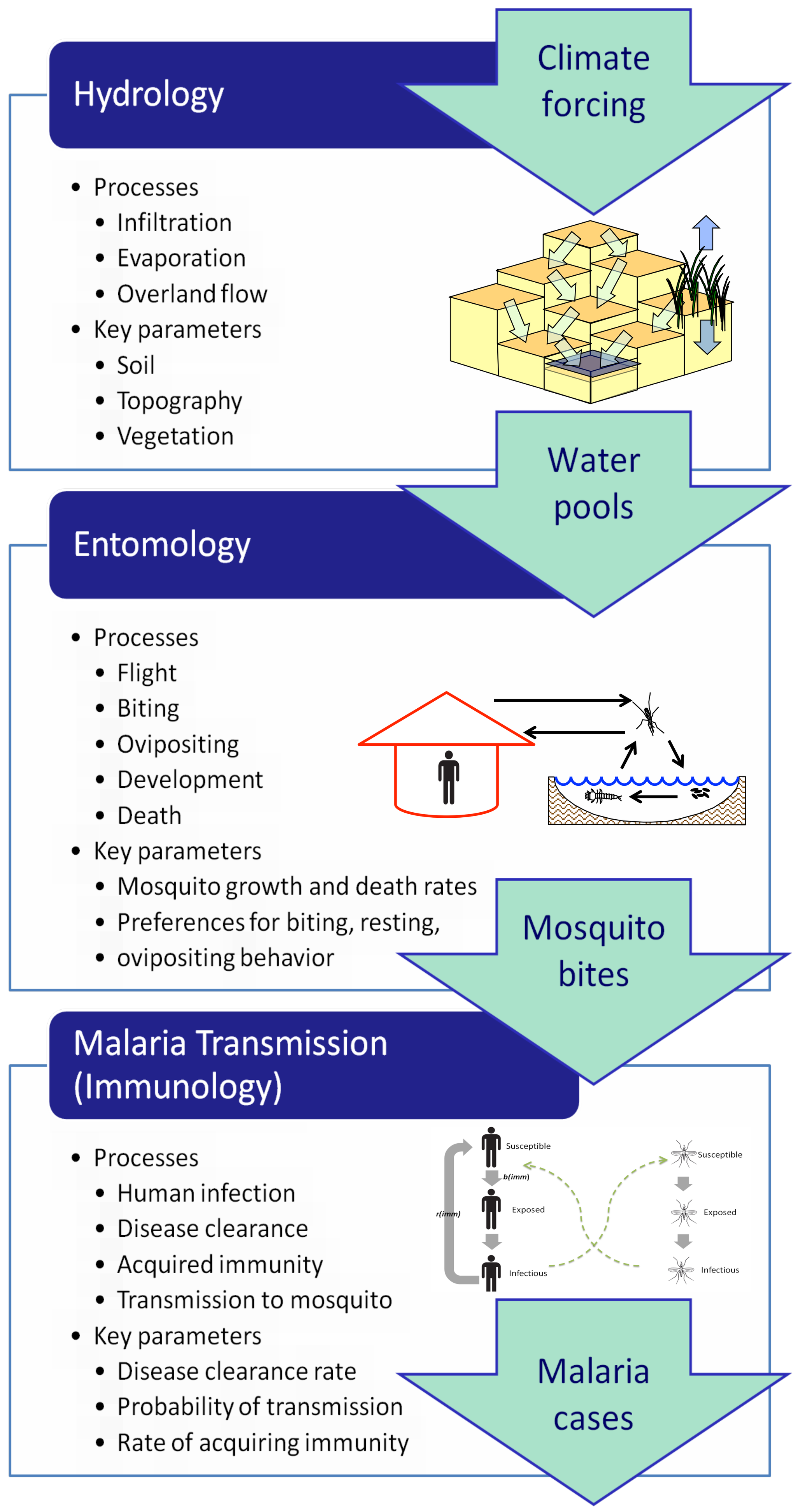
Climate change

The environmental drivers of malaria transmission are highly correlated. In West Africa, areas that are too dry for malaria are also too hot for malaria. Statistical relationships between environmental variables and malaria prevalence based on current climate patterns cannot be assumed to be valid as climate patterns change. Using a mechanistic model, we can use predictions from climate models to evaluate impacts of climate change.



Source: Yamana & Eltahir, 2013

HYDREMATS Model overview



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Further information

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