The Malaria Community Level Model.

A Decision-Making Support Tool to Formulate Effective IVM Strategies.

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Abstract

- This study proposes a simulation-based decision-making support tool to facilitate the design of effective location-specific IVM strategies. The simulation model synthesizes existing research and expert insights, and is developed by way of the System Dynamics methodology.

- (A simple and generic version of the model presented in this paper has been introduced in a previous paper “Statics and Dynamics of Malaria Transmission: The Relationship between Prevalence in Humans and Mosquitoes” also submitted for the System Dynamics conference 2020. In this sense, the present paper is a practical implementation of the generic model in order to assess the impact of malaria control interventions in a specific location)

- Preliminary calibration results in Malindi (Kenya) highlight the ability of the model to capture the major dynamics of the disease diffusion and its ability to represent IVM interventions.

Introduction

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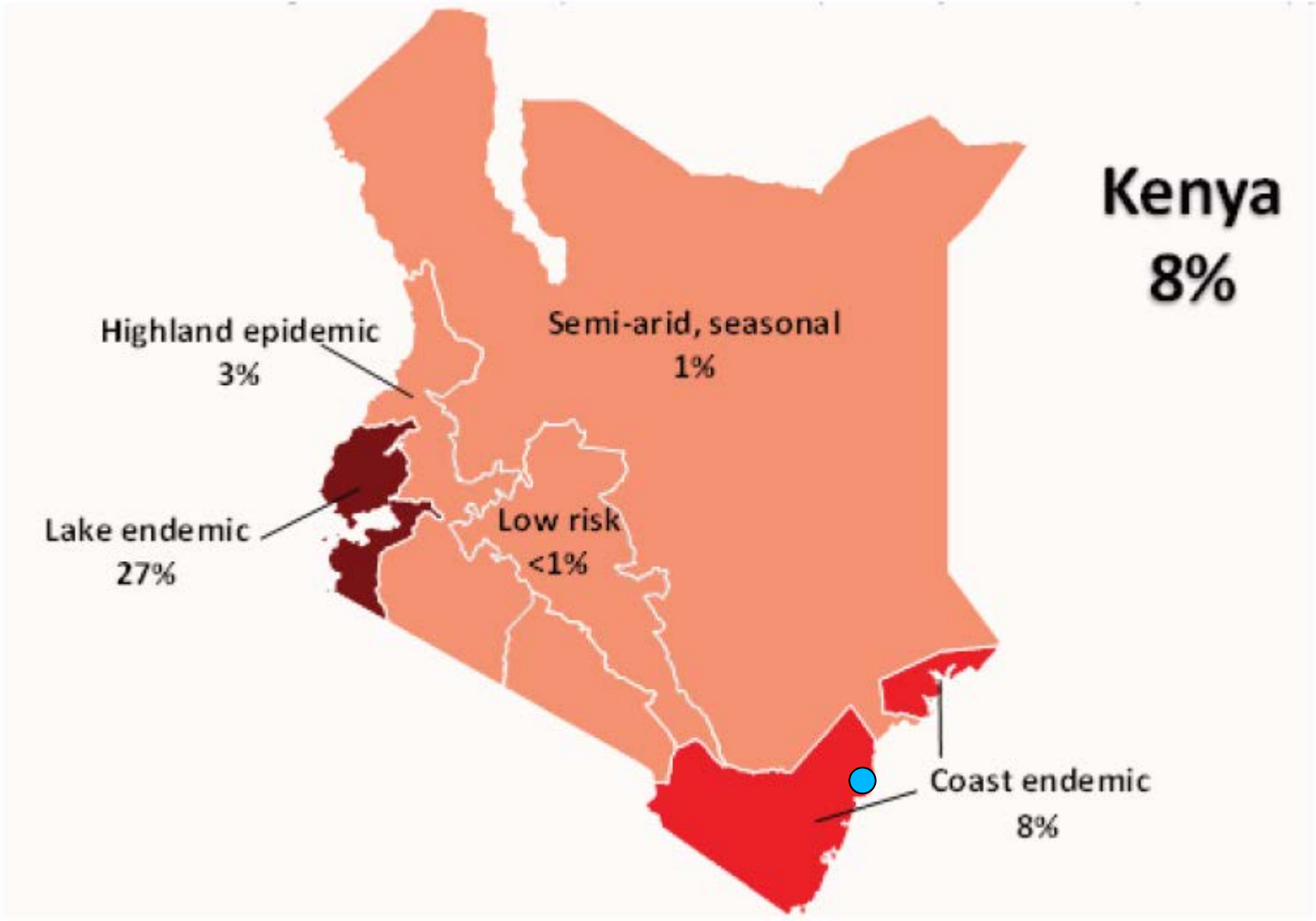
- The present study deals with a model-based decision-support tool to facilitate the design of effective location-specific IVM strategies.
- The model synthesizes existing research and expert insights, and is developed by means of the System Dynamics methodology.
- Preliminary results in endemic zones in Kenya and Ethiopia highlight the ability of the model to capture the major dynamics of the disease's diffusion and its ability to represent IVM interventions.

Location

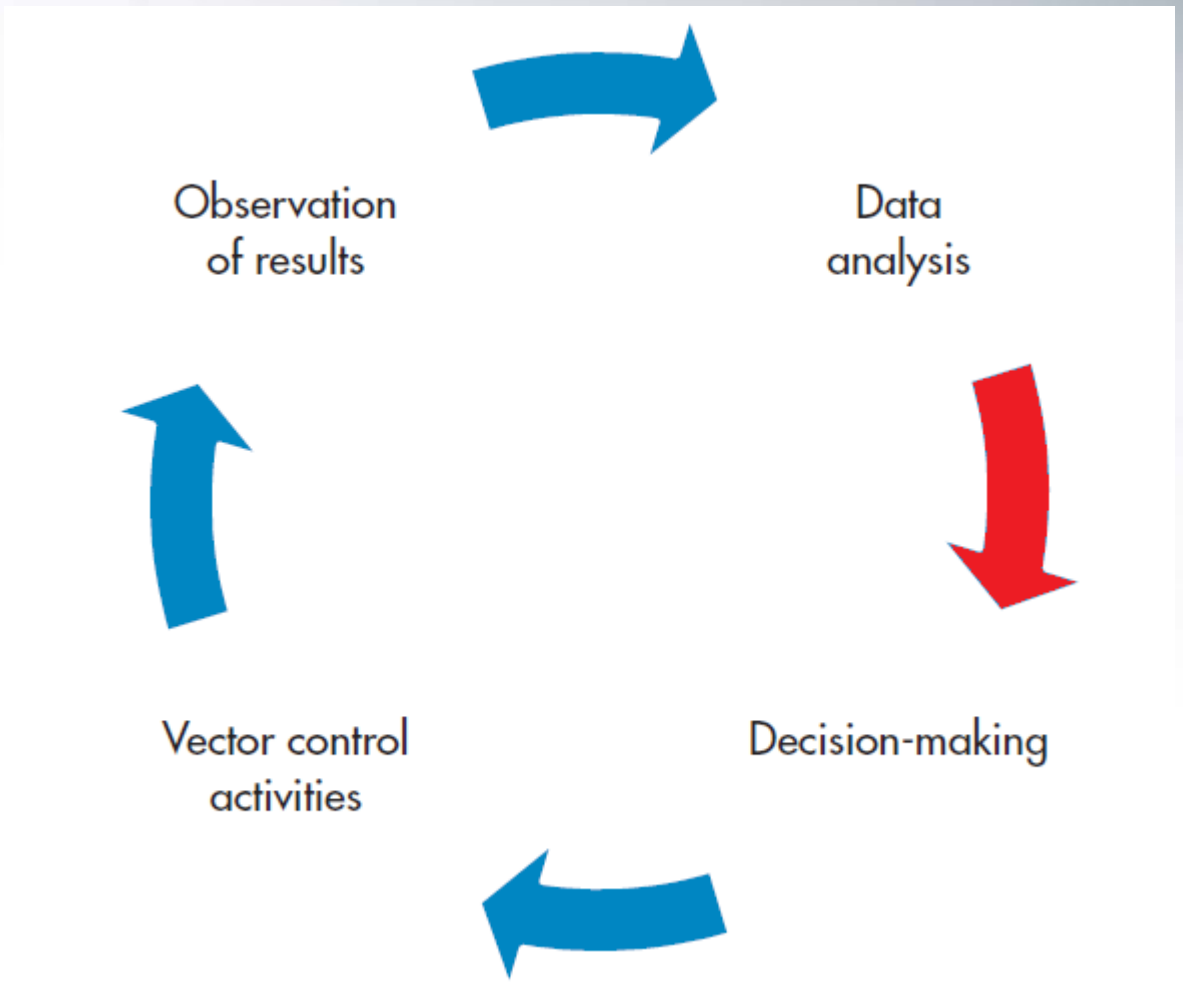

S. Sudan
Ethiopia
Somalia
Uganda
Rep. Congo
Kenya
Tanzania
Malindi

Location



Source: Kenya Malaria Indicator Survey 2015

Decision-Support Tool



Determinants of malaria transmission

ENVIRONMENTAL FACTORS

- **Climatic Factors**
  - Temperature
  - Rainfall and humidity
  - Seasonality of climate

- **Topography**
  - Altitude
  - Frost

- **Land change**
  - Weather events: hurricanes, floods and droughts
  - Stagnant water: permanent breeding sites
  - Man-made changes to the environment

Determinants of malaria transmission

SOCIO-ECONOMIC FACTORS

- **Poverty**
  - Malnutrition
  - Health Assistance
  - Literacy rate

- **Human density**
  - Urban areas
  - Migration
  - Refugee camps

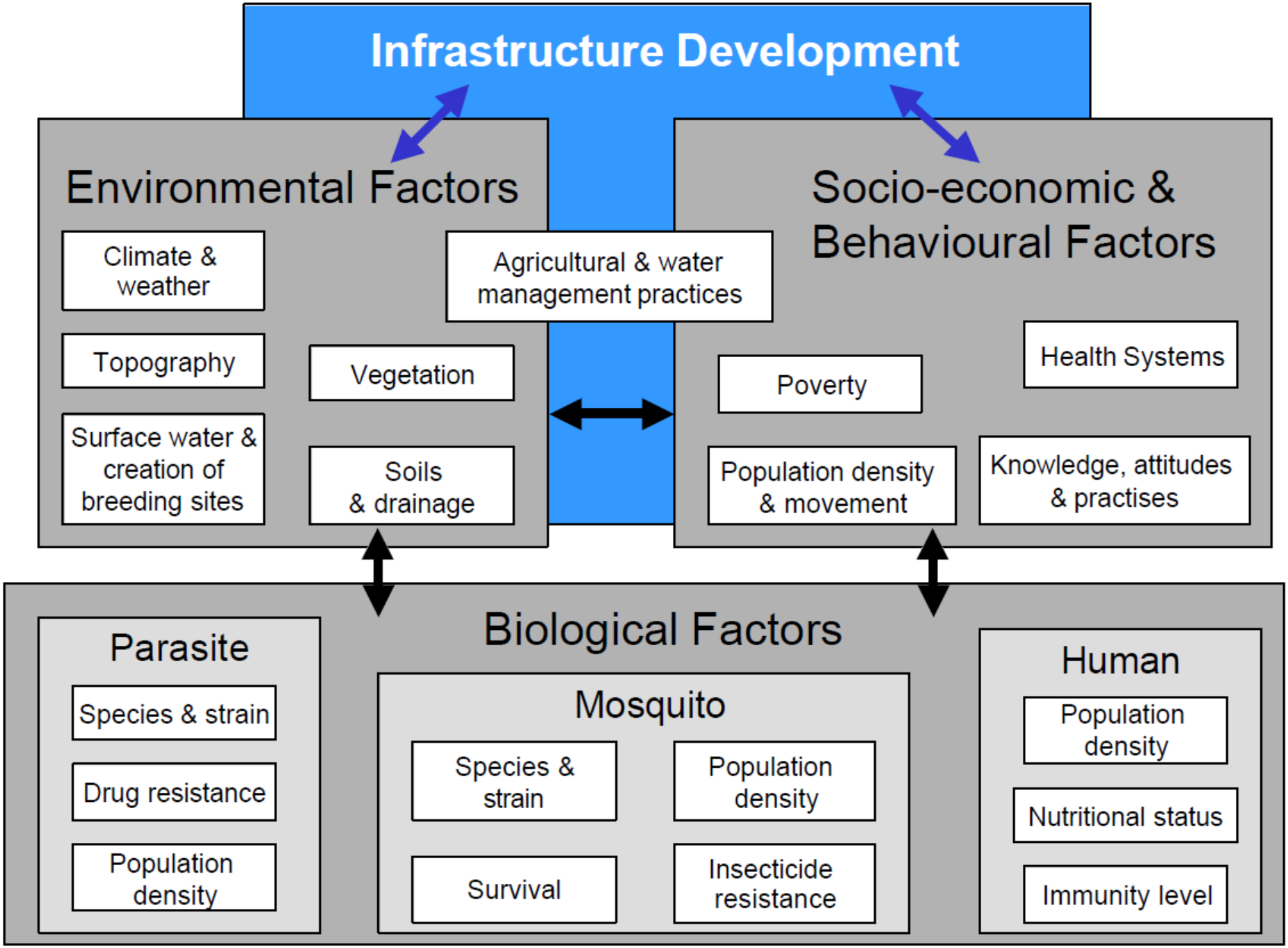
- **Health Control Measures**
  - Prevention coverage: LLIN, IRS, EM
  - Treatment coverage: RDT, ACT’s

Determinants of malaria transmission

BIOLOGICAL FACTORS

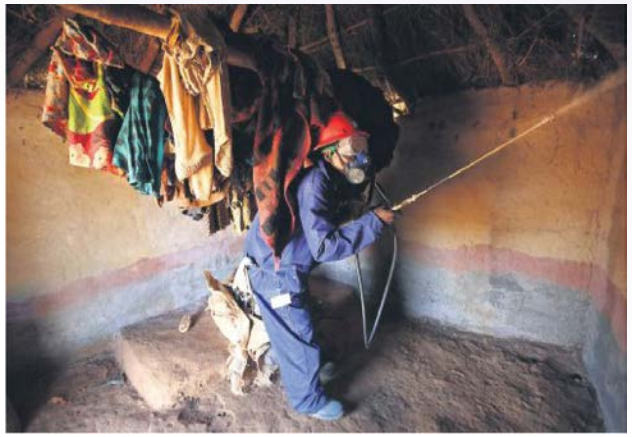
- **Human Immunity level**

- **Vector and parasite densities**
  - New species
  - Behaviour
  - Predators
  - Strains resistant against insecticides or drugs


Infrastructure Development
Environmental Factors
Climate & weather
Topography
Surface water & creation of breeding sites
Vegetation
Soils & drainage
Agricultural & water management practices
Socio-economic & Behavioural Factors
Poverty
Population density & movement
Health Systems
Knowledge, attitudes & practises
Biological Factors
Parasite
Species & strain
Drug resistance
Population density
Mosquito
Species & strain
Population density
Survival
Insecticide resistance
Human
Population density
Nutritional status
Immunity level

Integrated Vector Management

A rational decision-making process for the optimal use of resources for vector control



Its goal to make a significant contribution to

the prevention and control of vector-borne diseases.

Malaria control interventions

- **Integrated vector management (IVM)**
  - Protective measures, e.g. ITN's and LLIN's
  - IRS protection.
  - Source reduction: Environmental management, Larviciding.
  - Sensitization.

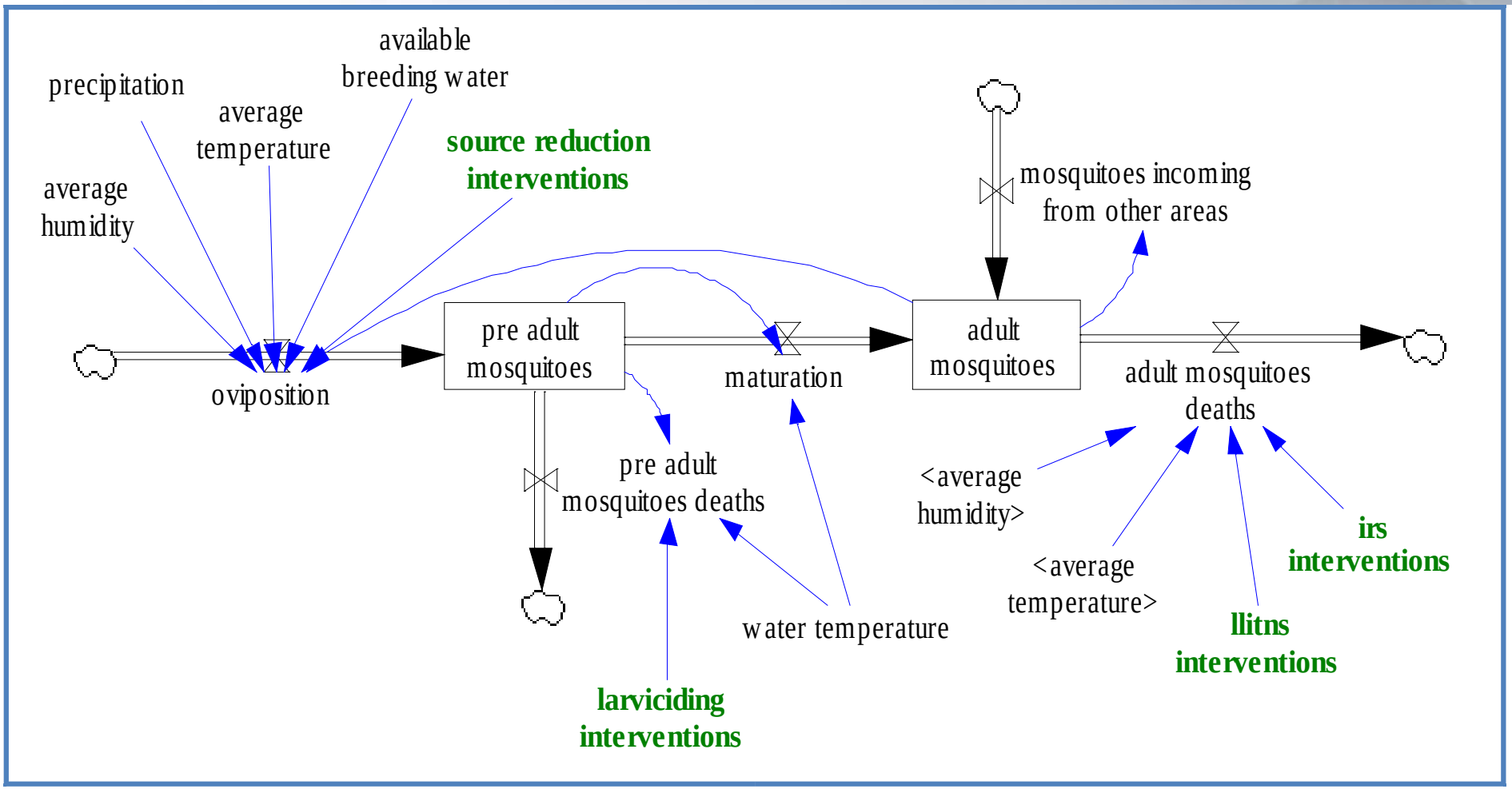
- **Case Management**
  - Artemisinin-based Combination Therapies (ACTs)
  - Rapid Diagnostic Tests (RDTs)

Local Community Model

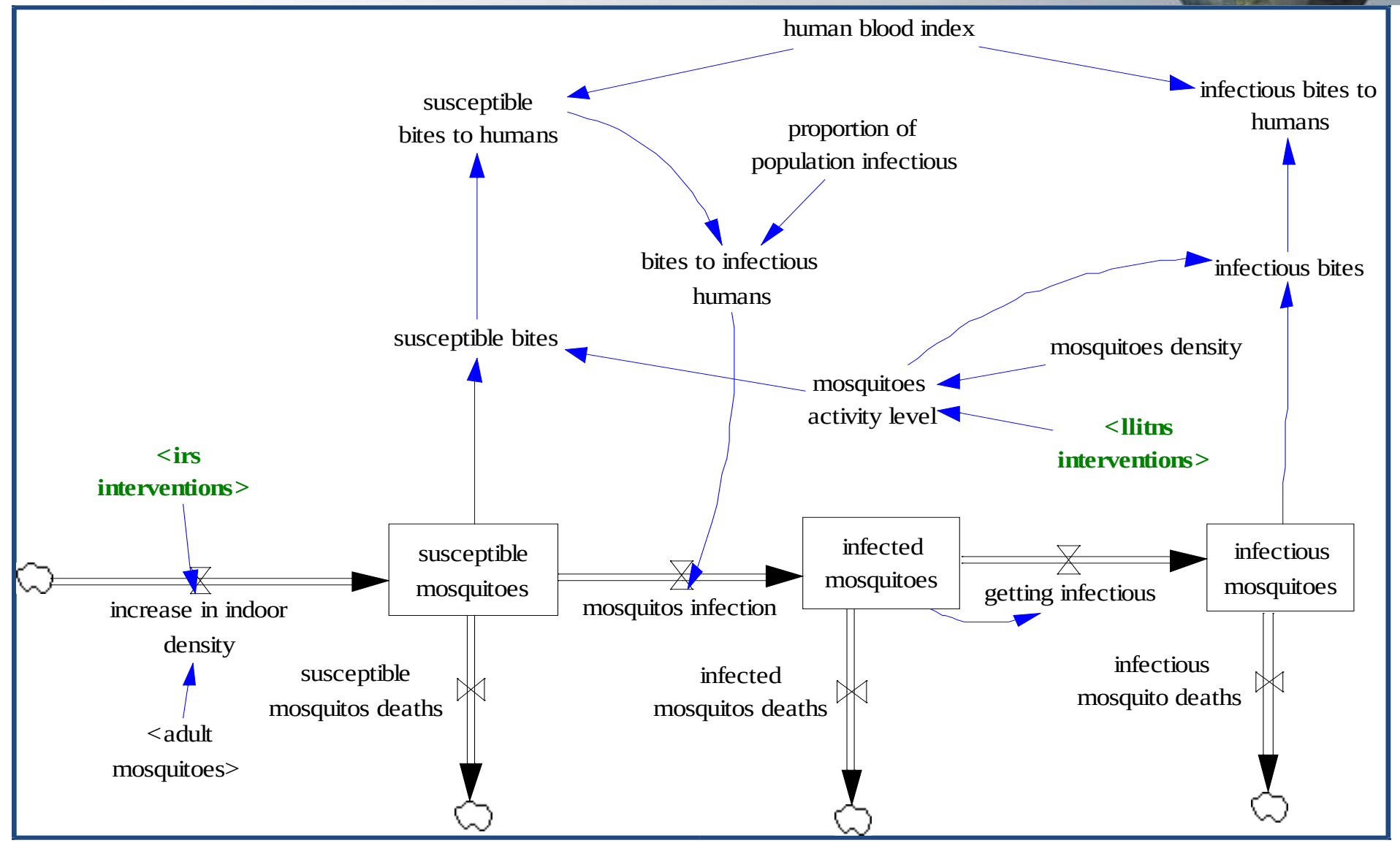
4 Sectors:

1. **Outdoor mosquitoes**
2. **Indoor mosquitoes**
3. **Human population and infections**
4. **Interventions and cost-effectiveness**

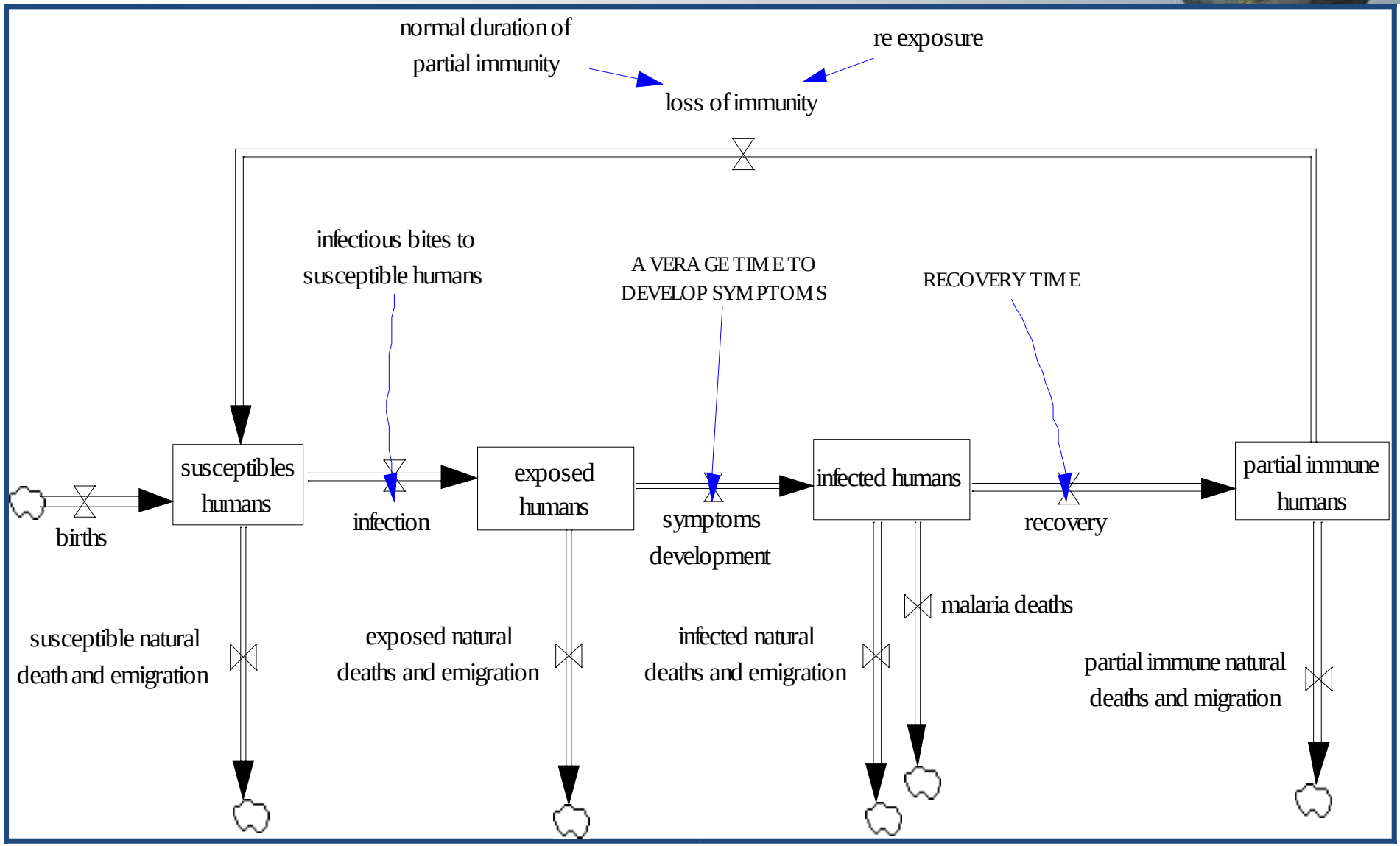
1. Outdoor mosquitoes



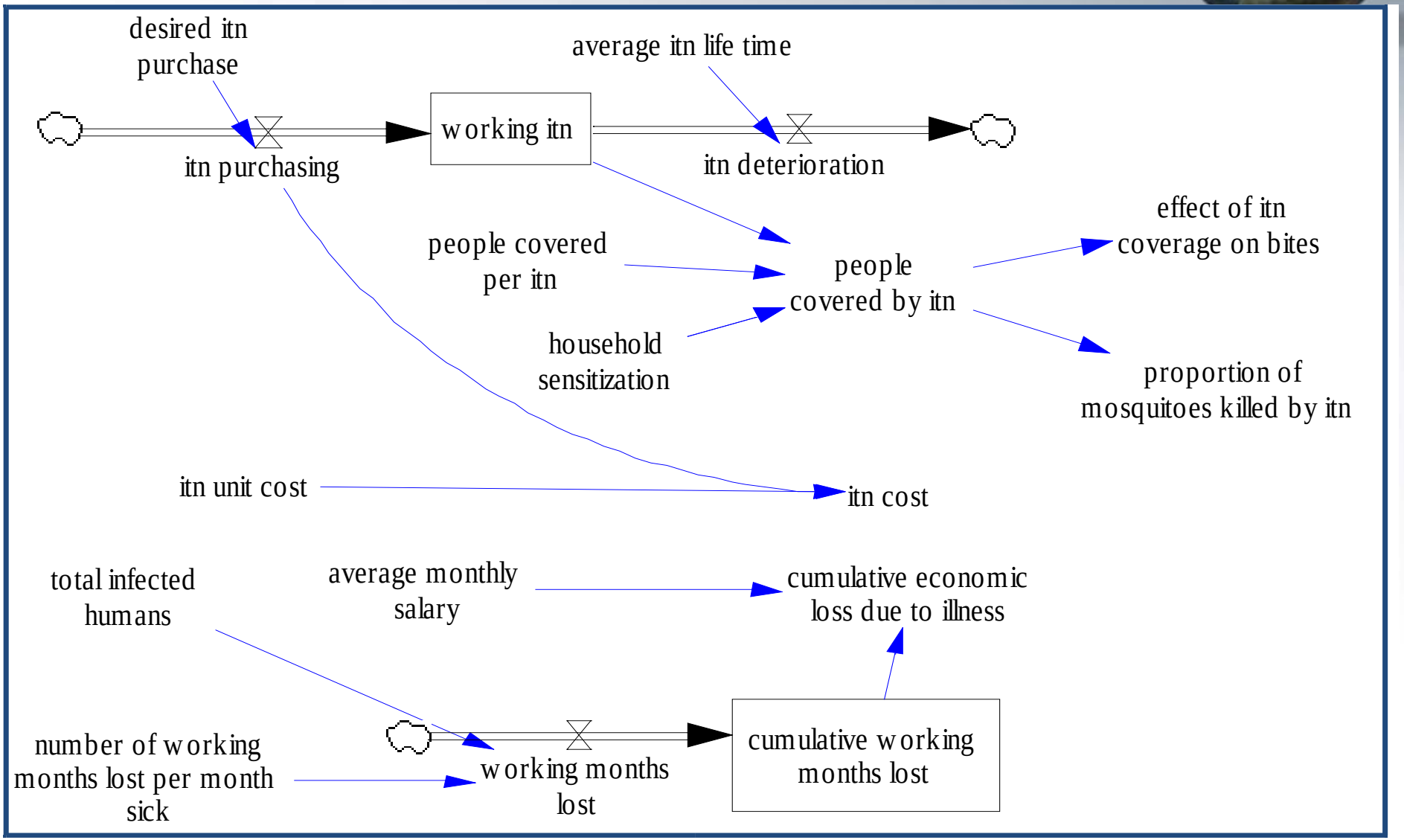
2. Indoor mosquitoes



3. Human Population



4. Interventions



Interventions Malindi

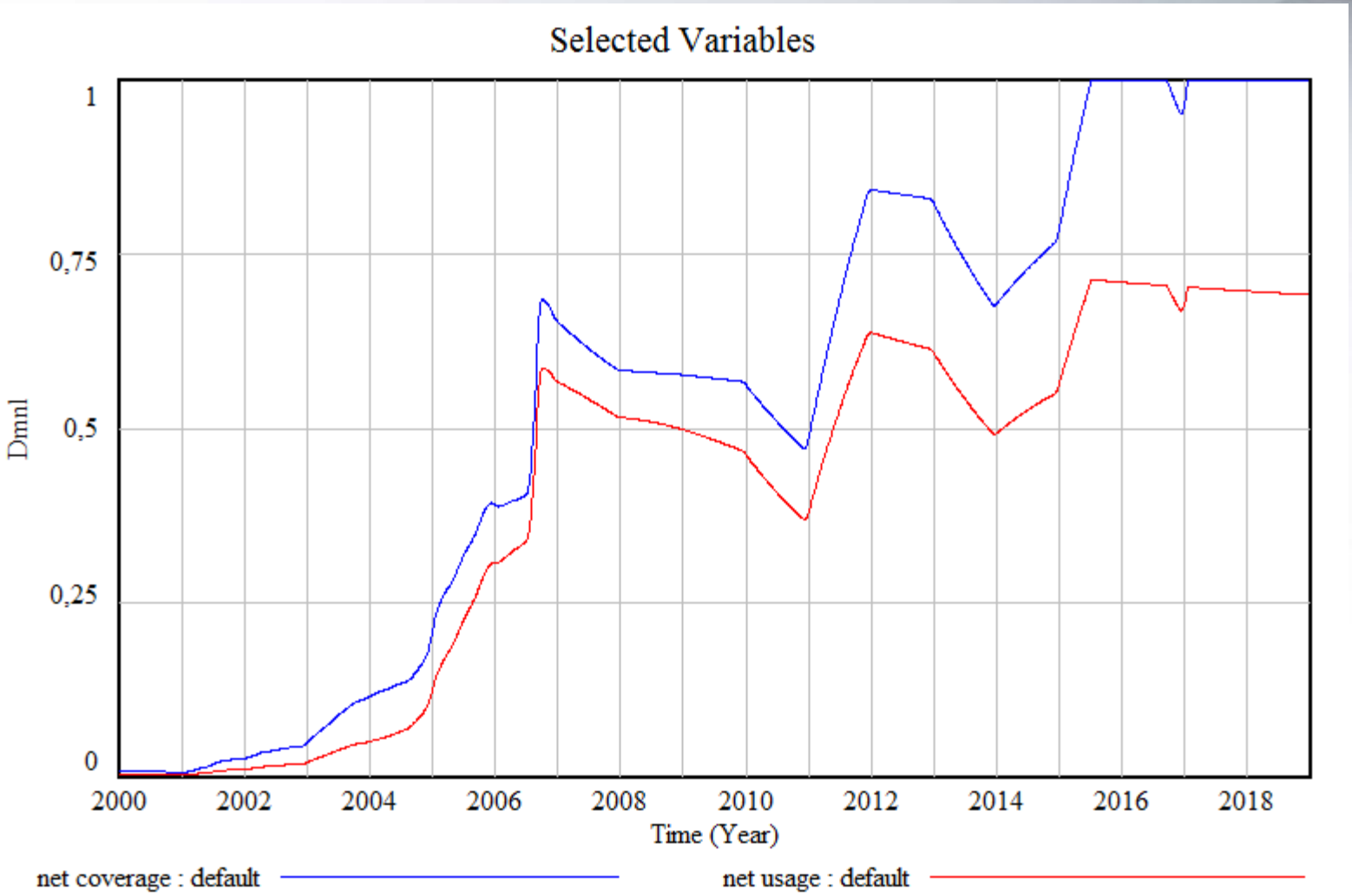
- Mass net distribution has been done in 2006, 2012 and 2015 in Malindi. In 2012 and 2015, the goal was to achieve universal coverage (1 net for 2 people) reaching 90-100% coverage.

- Sensitization campaigns are done every two weeks in Malindi. Awareness creation is related to environmental management (filling drains, etc), ITN use, and treating water bodies with larvicides.

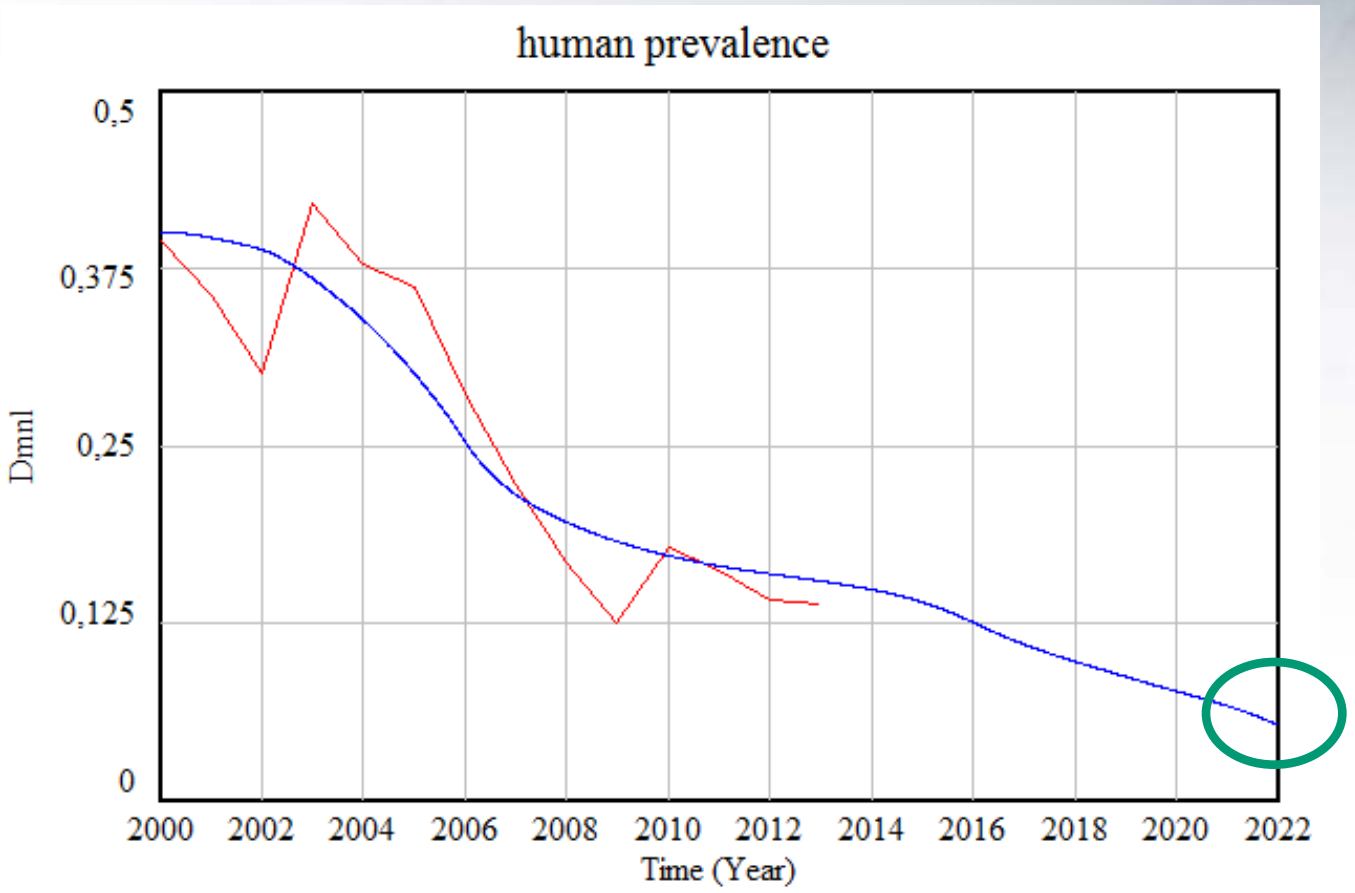
- Larviciding started in 2006 in Malindi. https://www.ncbi.nlm.nih.gov/pubmed/20730445

- IRS interventions have not been implemented throughout the period 2000-2015 in Malindi.

Interventions Malindi



Human Prevalence Malindi



Conclusions

The model developed in this paper is useful tool for simulating the impact of alternative Integrated Vector Management strategy scenarios based on the principles of comprehensiveness, flexibility and transparency.

Further research is geared towards applying the model in additional locations, to test its adaptability and its effectiveness for cost/effect analysis of alternative combinations of interventions.