Application of system dynamics in the analysis of economic impacts of Rift valley fever in Kenya

Karl M. Rich and Francis Wanyoike
International Livestock Research Institute

Presented at a Dynamic Drivers of Disease in Africa Consortium (DDDAC) project workshop
Naivasha, Kenya, 24–26 June 2014

Background

- In 2007, ILRI carried out a study of the socio-economic impacts of the 2006 RVF outbreak in Kenya

- Results shed light on how various VC actors were affected by the outbreak including also the macroeconomic impacts

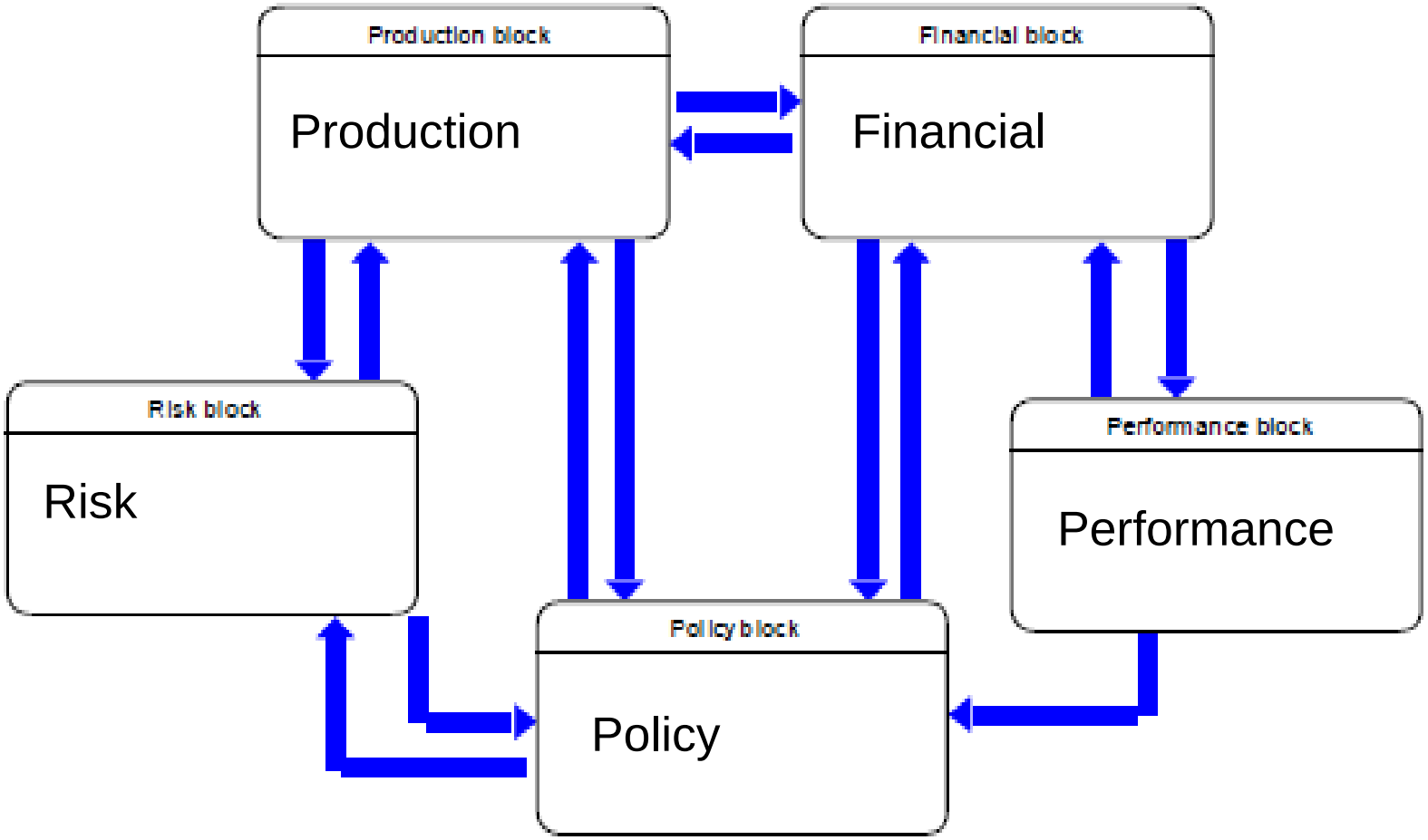
- The analysis we carried out was however static

- We now wish to conduct a more dynamic kind of analysis of the disease impacts and also simulate how these effects would change in the light of various interventions (policy or otherwise) that could be instituted

Use of SD in Disease impact analysis

- What is SD?
  - SD is a computer-aided approach to policy analysis and design
  - It applies to dynamic problems in complex social, managerial, economic, or ecological systems — such dynamic systems are characterized by interdependence, mutual interaction, information feedback, and circular causality.”
  - A methodology for studying complex dynamic systems that include nonlinearities, delays, and feedback loops
- When used in analysis of disease impacts, SD provides a way to integrate epidemiological and economic and other impacts in one platform
- This method has been used by ILRI in Botswana to analyze the impacts of FMD outbreaks on trade and competitiveness (Hamza et al. 2014) and Cambodia(Rich and Roland-Holst 2013)

Conceptual framework



Motivation

- An integrated epidemiological-economic model captures 2 types of disease related impacts:
  i. Disease outbreaks that influences productivity or are associated with significant mortality, and also the control measures taken to control them will influence stocks of animals held by farmers

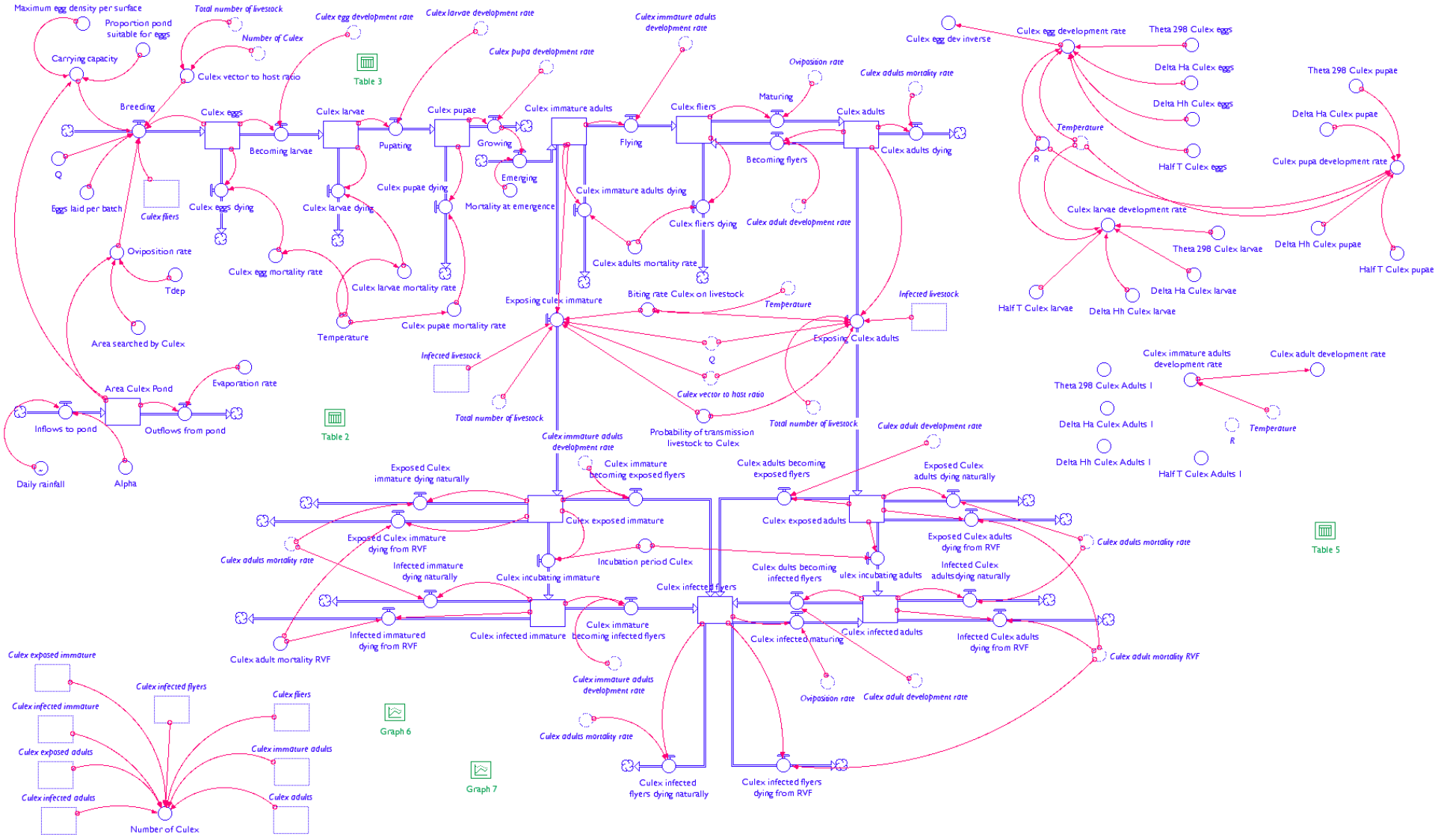
  ii. Animal diseases can have demand impacts, either by reducing domestic demand due to perceived food safety concerns or international demand through trade bans, or both

- Note that in both cases, feedback effects matter
  - When you have an outbreak, this influences behavior of actors (Distress selling by farmers) and this in turn influences the spread of the disease

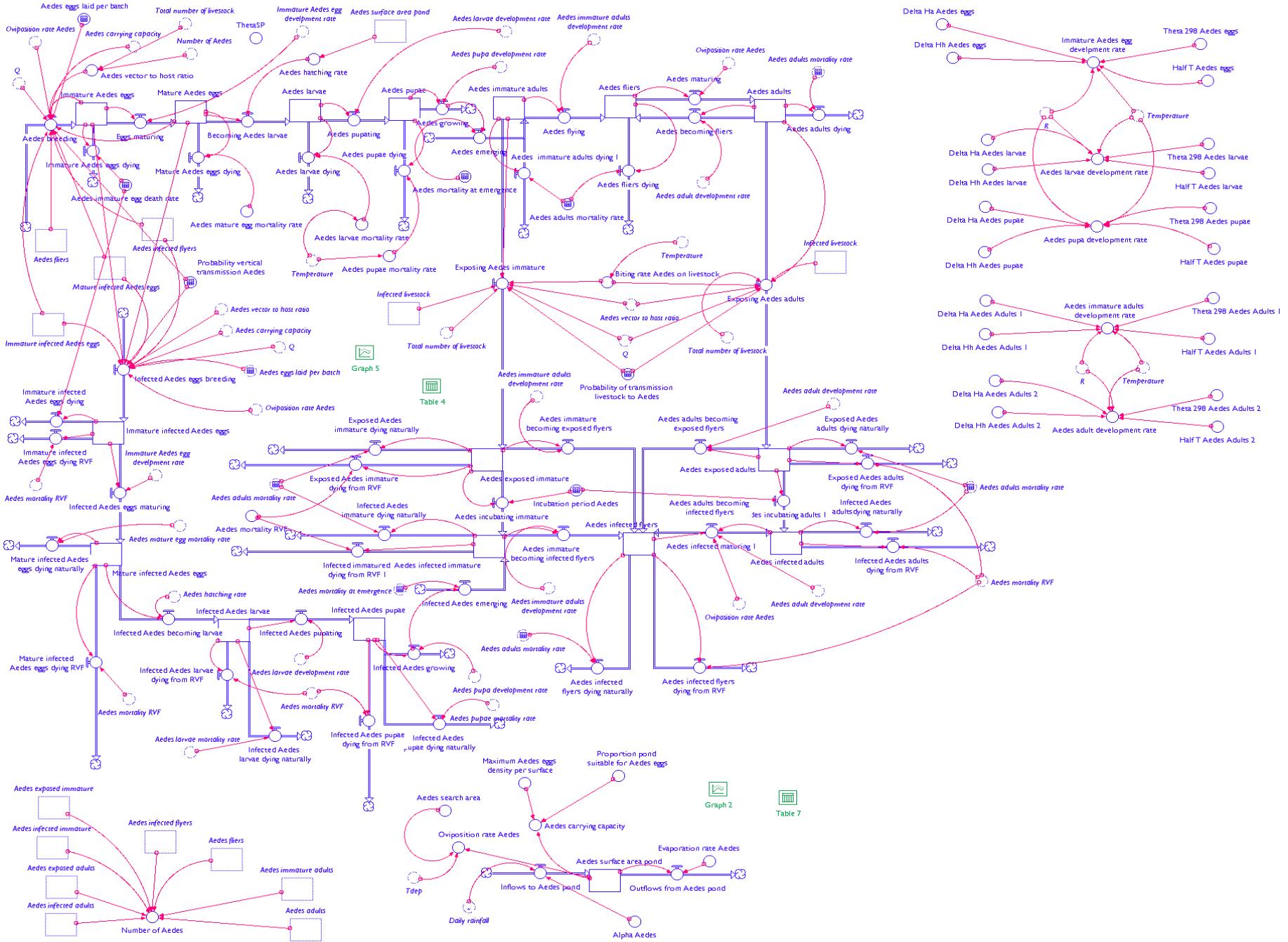
The Epidemiology module

- The diseases spread is based on the RVF transmission model of Gianni:
- Model captures dynamics of mosquito populations (Aedes and Culex) and their interactions with livestock
- The idea is to program the existing model from R into STELLA (a system dynamics software) to allow integration with other modules.
- Model has been parameterized based on R model, though a few aspects remain problematic (e.g., endogenizing sizes of ponds for mosquitos)

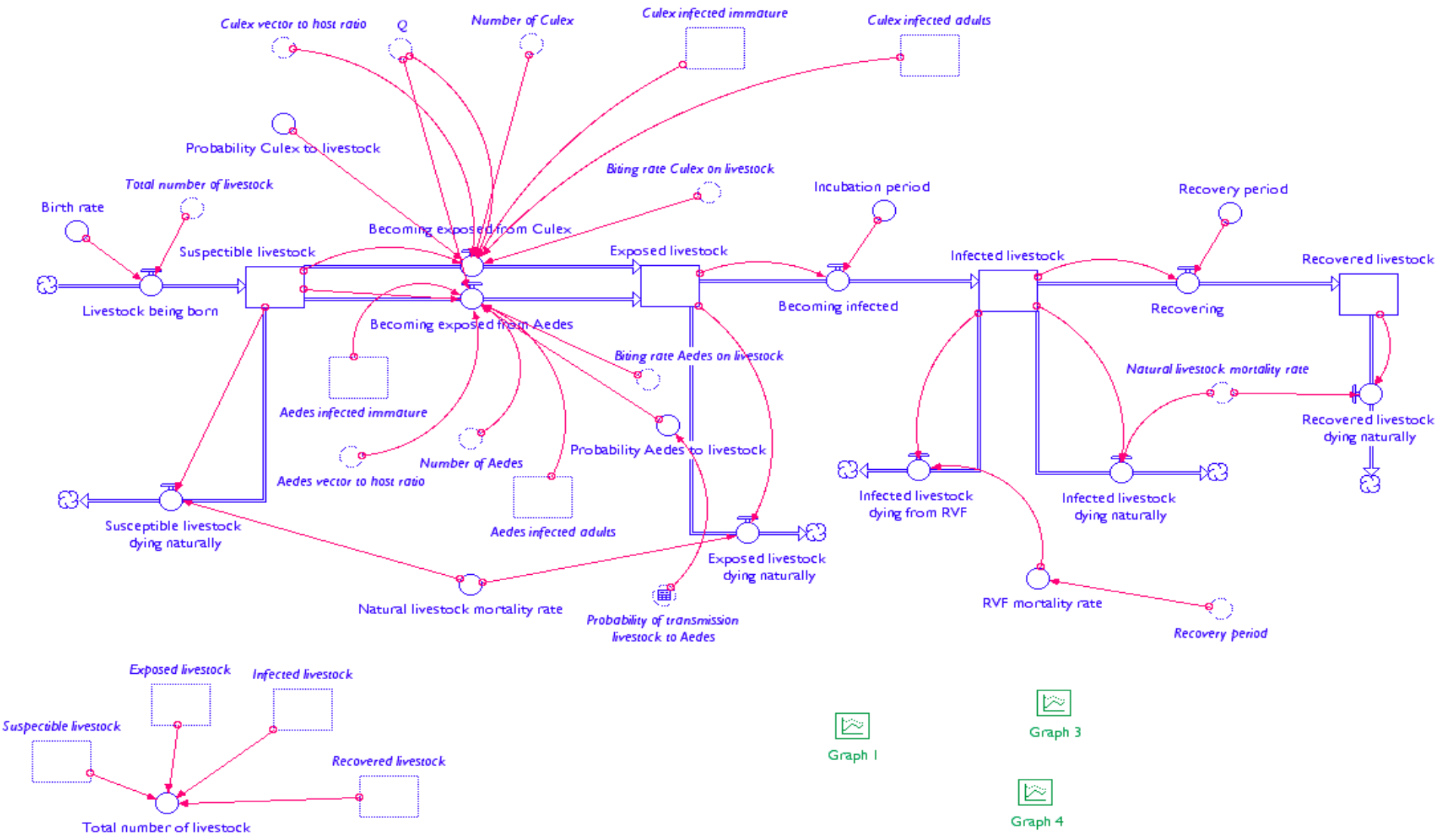
The Epidemiology module: Culex dynamics



The Epidemiology module: Aedes dynamics



The Epidemiology module: Disease spread dynamics



The economic/value chain module

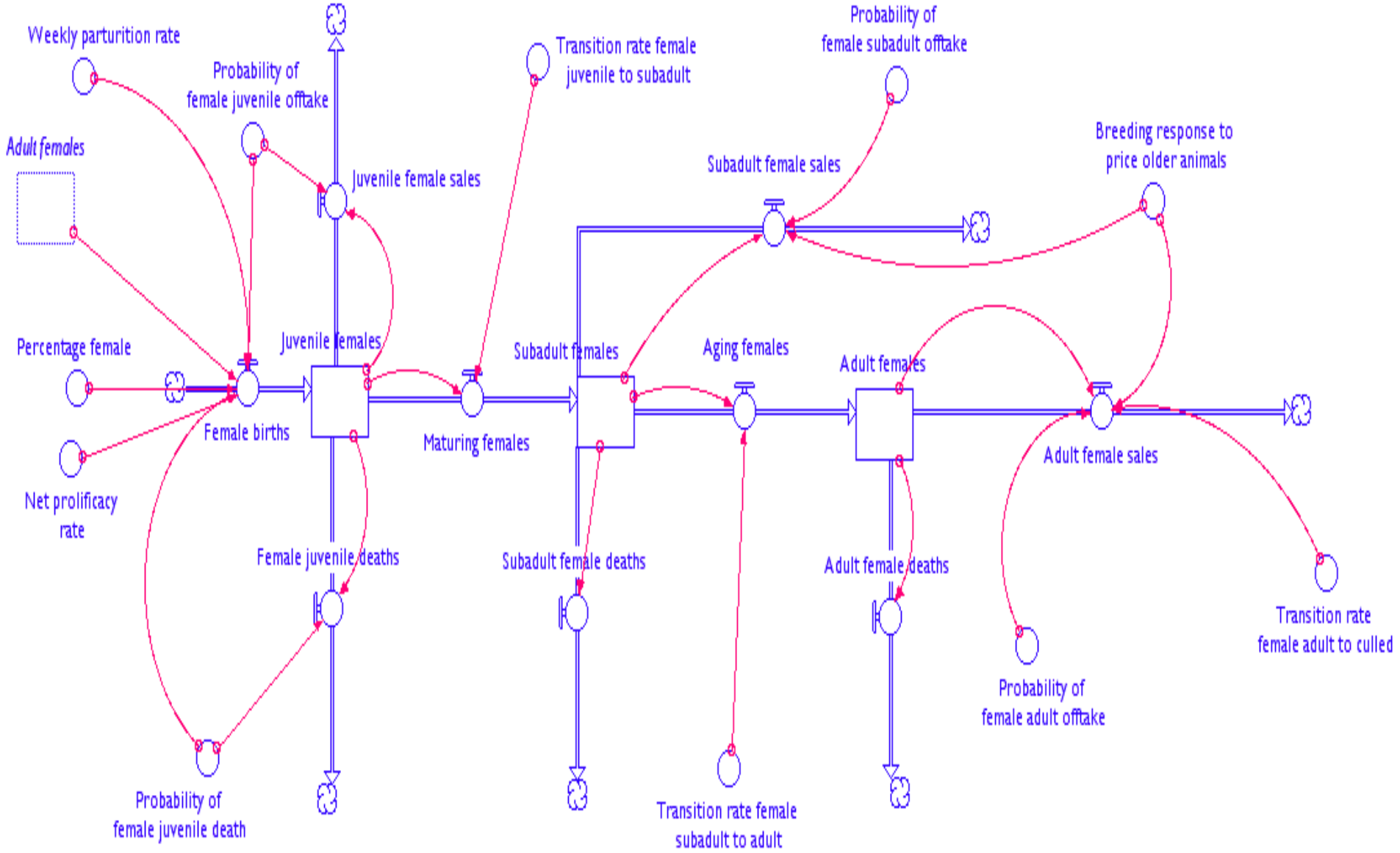
- The economics/value chain component also has 3 modules /sectors

  - Herd dynamics module: – based on the DynMod model developed by Lesnoff et al. (2008)

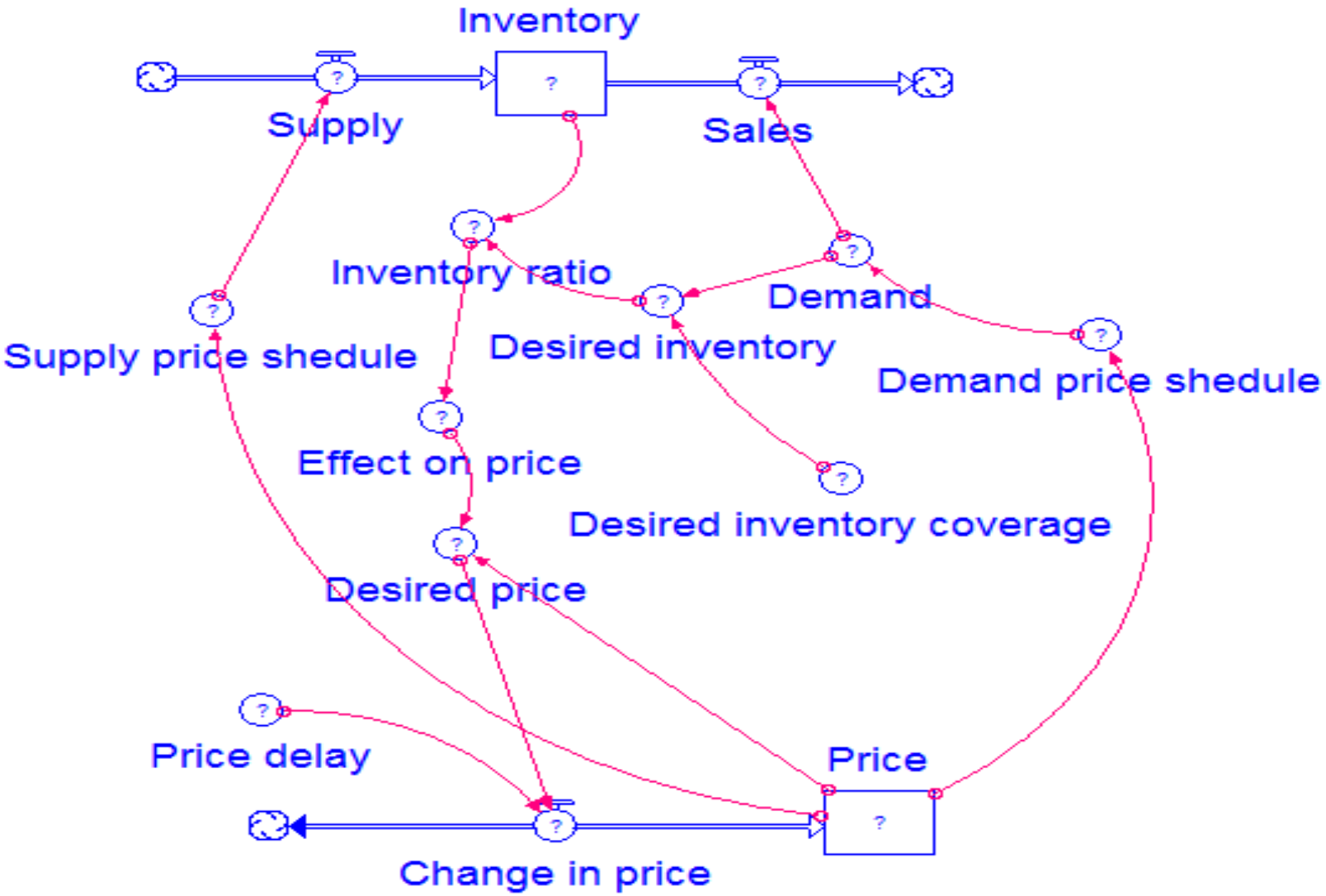
  - Market dynamics module: Based on the supply and demand model of Whelan and Msefer (1996).

  - Financial costs module

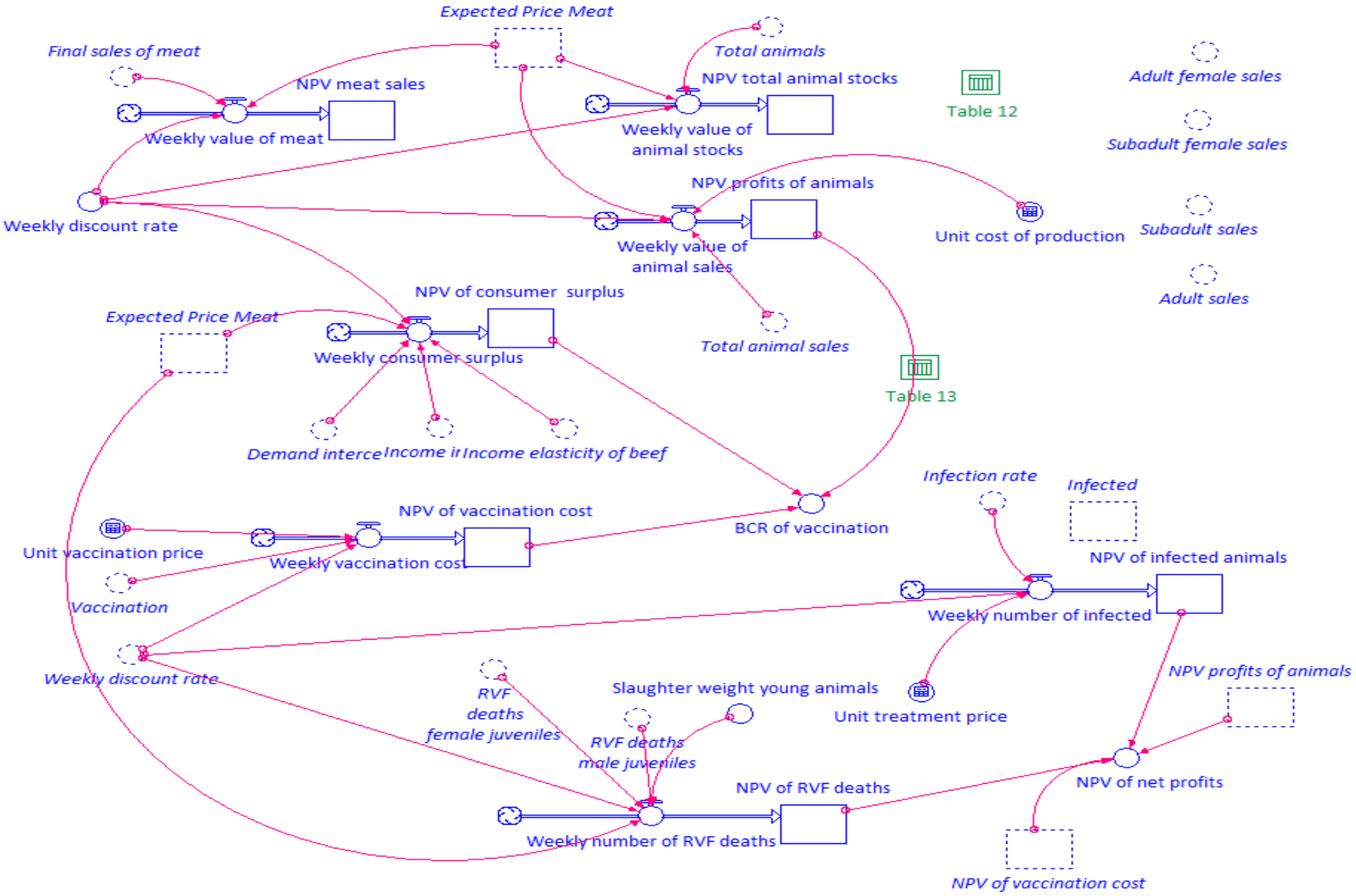
Herd Dynamics



Market dynamics module



Financial costs module



Results

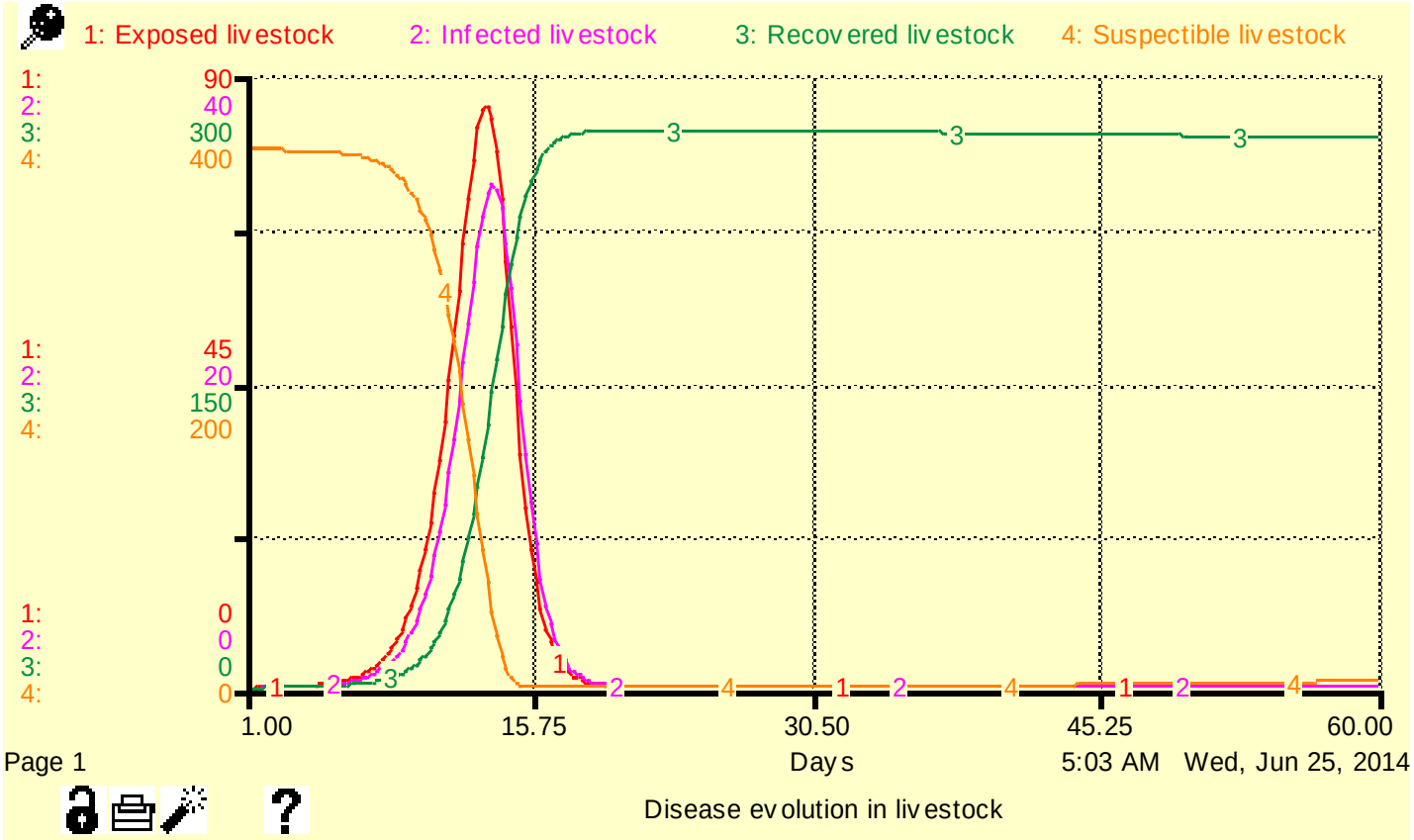
- The model is still under construction so the results shown below are just illustrative of how we aspire to use it

- The graphs simulate what happens to cattle population in Ijara district in the event of an RVF out break with and with out vaccination

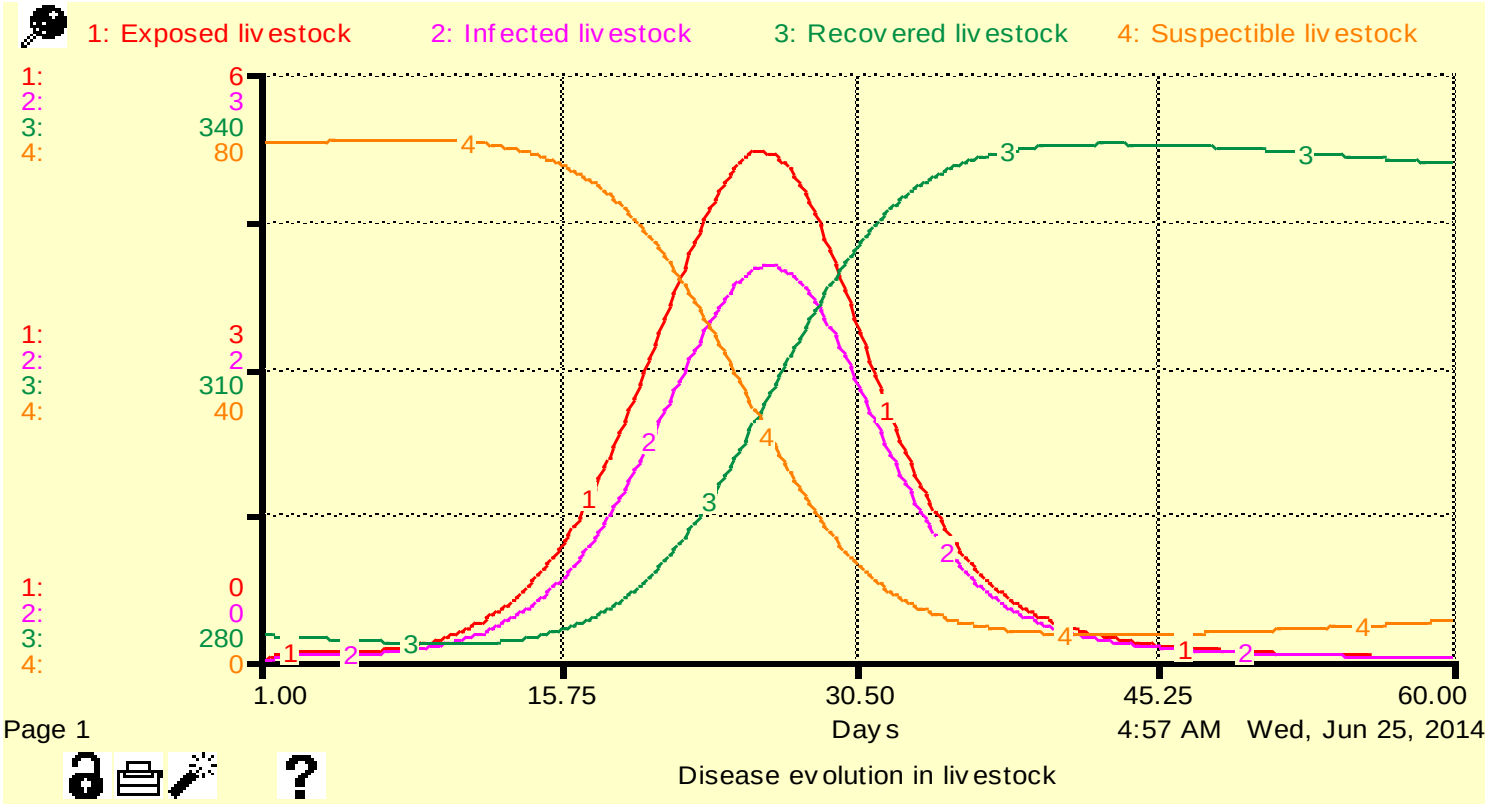
- Similar kinds of analysis will be done for value of livestock, costs, sales, prices etc.

Preliminary results

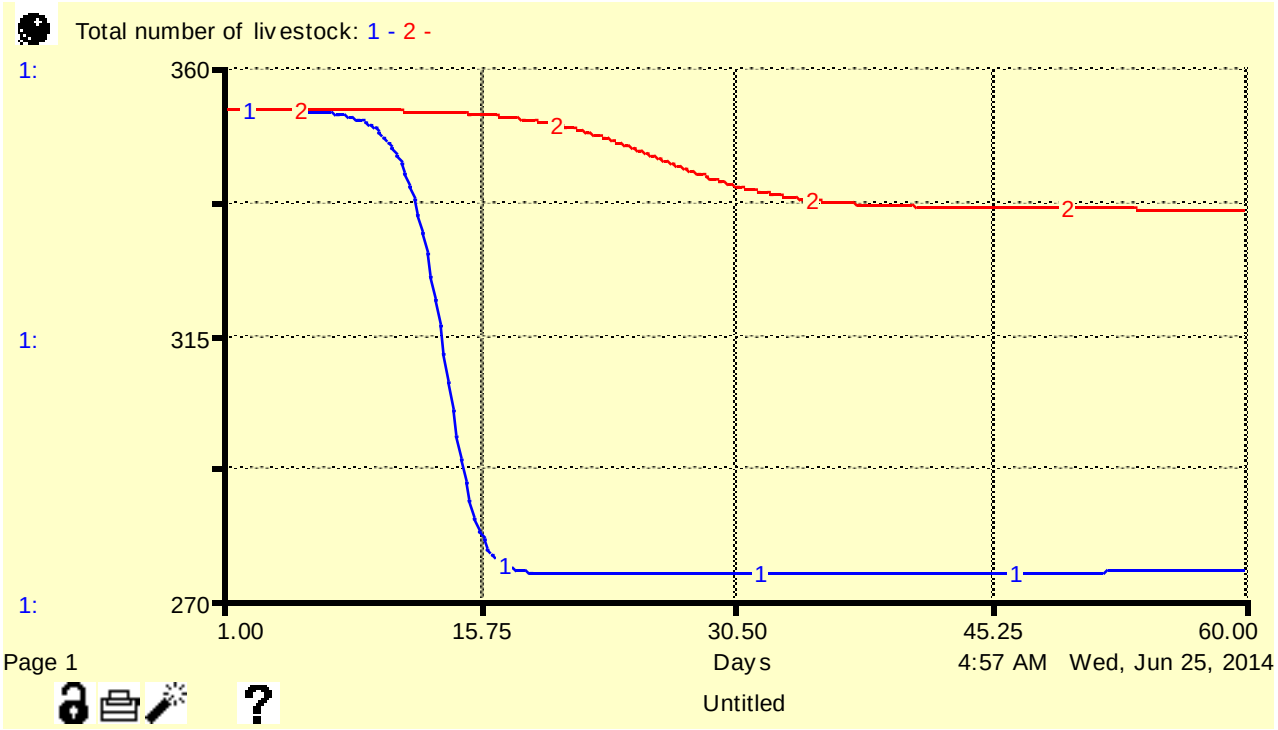
Disease evolution in the event of an outbreak with no vaccination



Disease evolution in the event outbreak but 80% of animals had been vaccinated



Total number of animals with and without vaccination



Thank you

International Livestock Research Institute