A System Dynamics Model for Emergency Logistics “Post-disaster” Jeddah, Saudi Arabia

By

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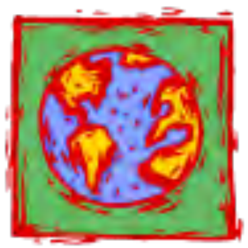
BACKGROUND

- Continuous changes happen deep inside the Earth and on its surface. The changes on the Earth happens due to the different kinds of weather.
- Natural disasters can cause damage to land, lives, Flora and Fauna
- Natural disasters are frightening and complex to understand.
- Epidemics caused by bacteria or viruses are called natural disasters under a different category.
- A biological threat such as locusts or toxic fungi, and an outbreak of SARS, EBOLA can also be considered a natural disaster.



TYPES OF NATURAL DISASTERS

- Earthquake
- Cyclone or Hurricane
- Volcanoes
- Avalanche
- Flood
- Drought
- Forest or Bu

INTRODUCTION

- Natural disasters have significant impacts:
  - Social Lives
  - Physical infrastructures
  - Economic developments,
  - Education and Health
- Create challenge for authorities, emergency and rescue departments, relief organizations if they are not equipped with appropriate disaster planning models.
- Around 20-25 billion US dollars are spent for emergency response each year.
- By reducing this cost, more resources can be directed into the reconstruction & EL effort.

Emergency Logistics

- EL is characterized by various stakeholders A major challenge is how to coordinate all relevant parties.
- EL in disaster response can be viewed as temporary supply chains set up for particular operations.
- A major problem is whether traditional models can or should be applied for the temporary and non-commercial systems that characterize EL.
- Due to many challenges arising within EL, there is an emerging need to develop new methodologies or new variants of old ones.

Disaster management approach: clustering

Source OCHA 2013 Cluster coordination

OBJECTIVES

The objectives of this paper aim to

- **Illustrate how managers can use system dynamics modelling**,

a) *To learn the behaviour of complex systems with multiple feedback effects and,*

b) *Long time delays, accumulations of diverse important factors,*

c) *Nonlinear responses to decisions.*

- ***Also, to develop a:***

4. *Dynamic model based on field level inputs.*
5. *Allowing quicker response which minimises time and cost.*

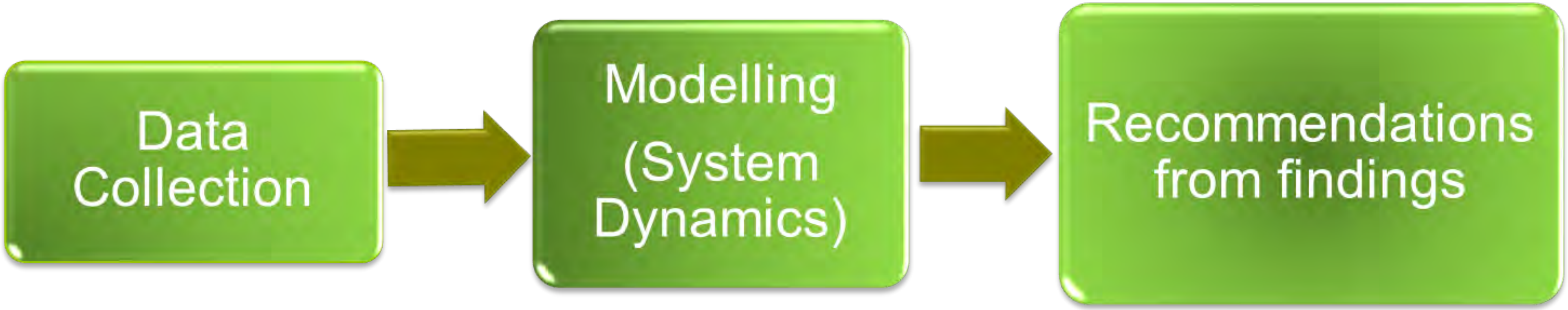
Scopes

The scope of this paper is to:

To construct a **system dynamics model** for logistics management;

- To develop policies for quick action
- To develop dynamic logistics coordination models.
- To develop better support coordination in disaster situations.
- Adaptation for similar sea ports prone to natural disasters such as flood, fire, earthquake or tsunami.

RESEARCH METHOD



- Saudi Arabia
- Saudi Arabia
- Saudi Arabia

RESEARCH METHOD (cont.)

Data Collection and Analysis:

- Data from disaster zones and affected people
- Uses of modern technology including communication technology.
- Filter data
- Prioritise data and devise action plan
- Implementation and Effective Coordination in disaster zones

RESEARCH METHOD (cont.)

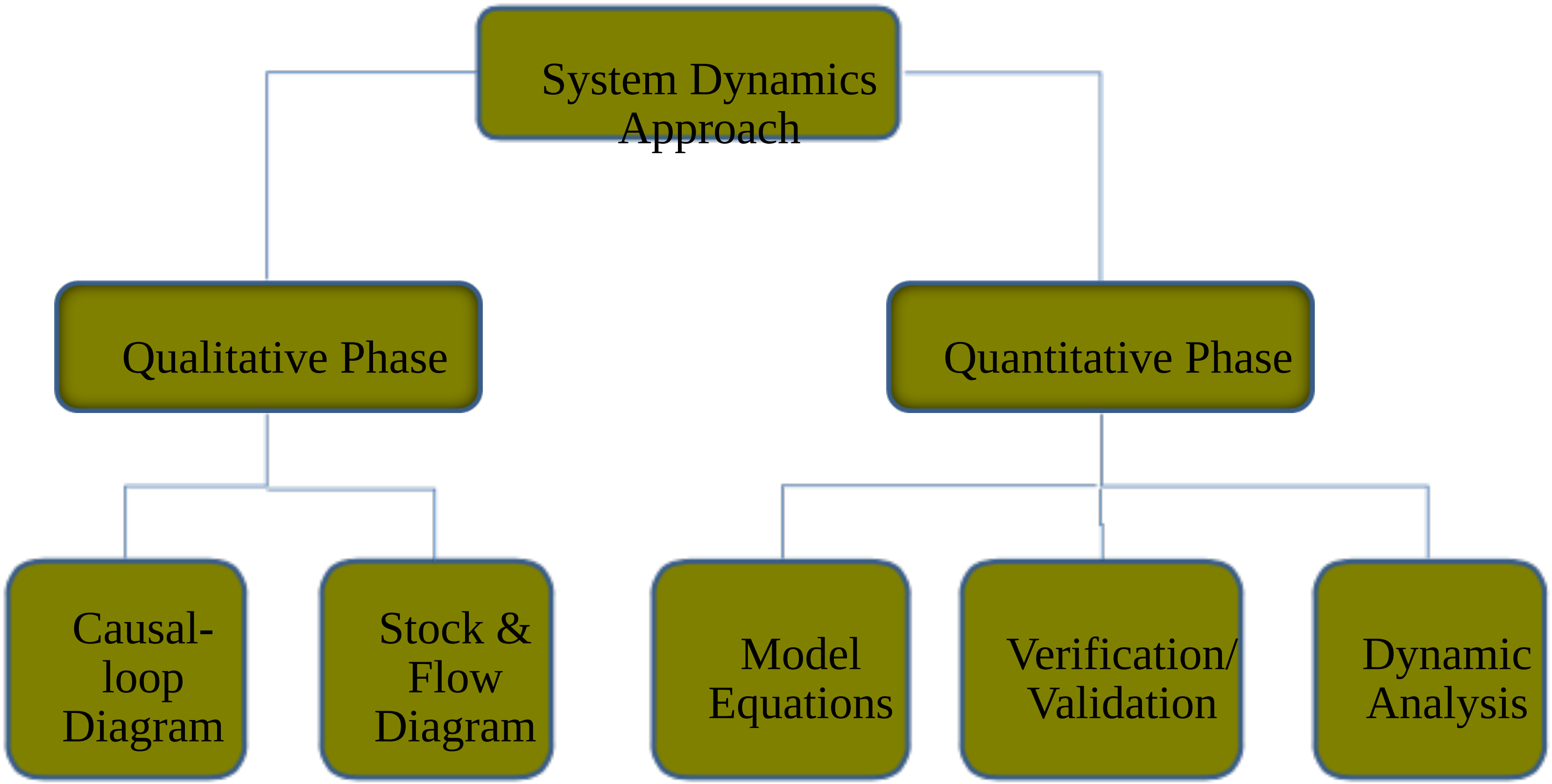
Modelling

- Models relevant to disaster relief (currently used) will be analysed, particularly in system dynamics modelling with stochastic and dynamic parameters, uncertainty that can accept data streams as changes occur.

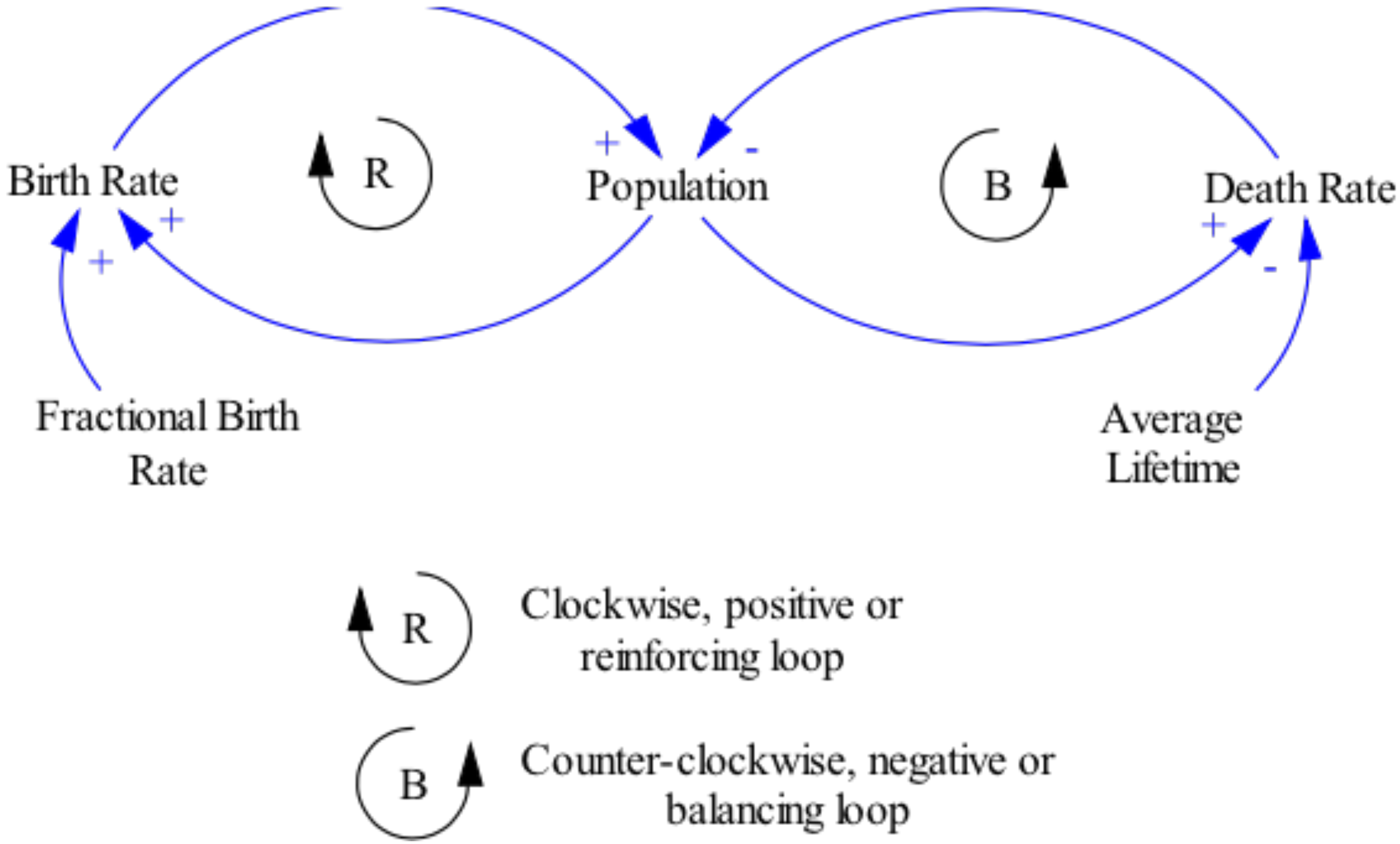
- An appropriate model must incorporate different actors, time delays, uncertainty and multiple feedback loops. System Dynamics (SD) modelling has a significant impact on the way we assess the interactions among variables in emergency operations.

- From this information and research, a mathematical model has been developed to process data available from the case studies, and refine until it meets criteria to maximise the efficiency of rescue operations: Communications, Coordination and Rescue Logistics.

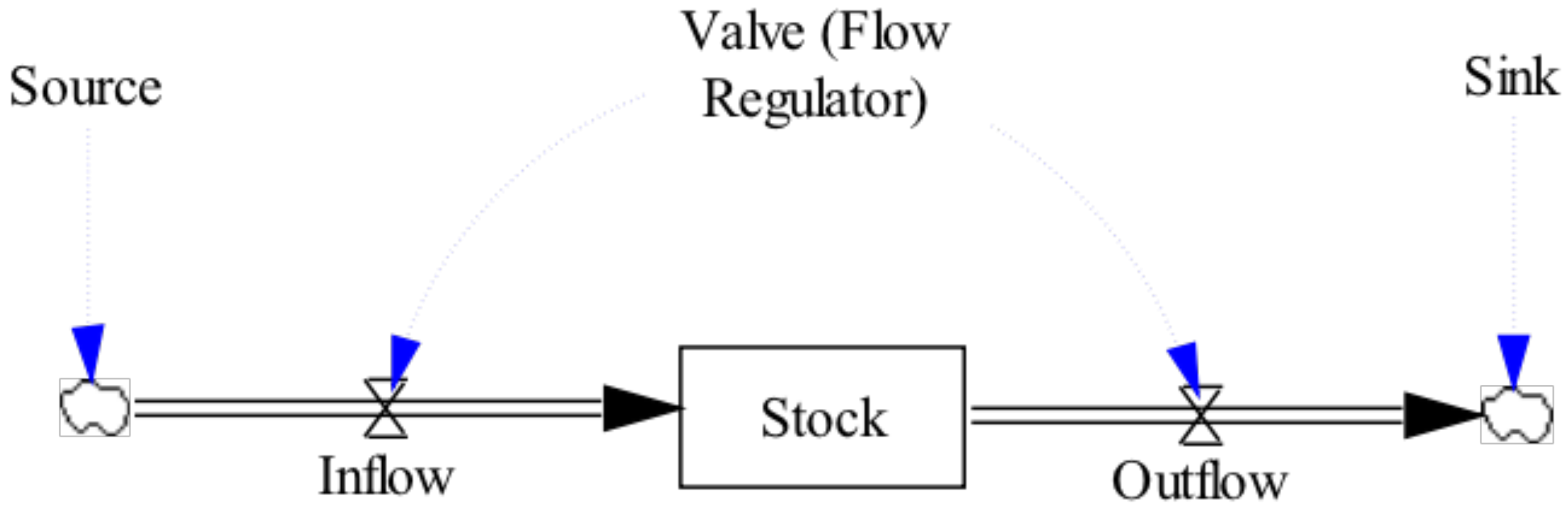
System Dynamics Methodology



Causal Loop Diagram



General Structure and Notation of Stock and Flow Diagram



Mathematical Representation of Stocks and Flows

$$Stock(t) = \int_{t_0}^{t} [Inflow(s) - Outflow(s)]ds + Stock(t_0)$$

, where inflow(*s*) represents the value of the inflow at any time *s* between the initial time *t0* and the current time *t*. (Sterman, 2000)

Modelling using SD Software and its Simulation

- The stock and flow diagrams and the equations as the proposed system dynamics models are captured by a System Dynamics software, Vensim

- All parameter values in each system should be determined and entered into each model before simulation

Case Study “Jeddah City”

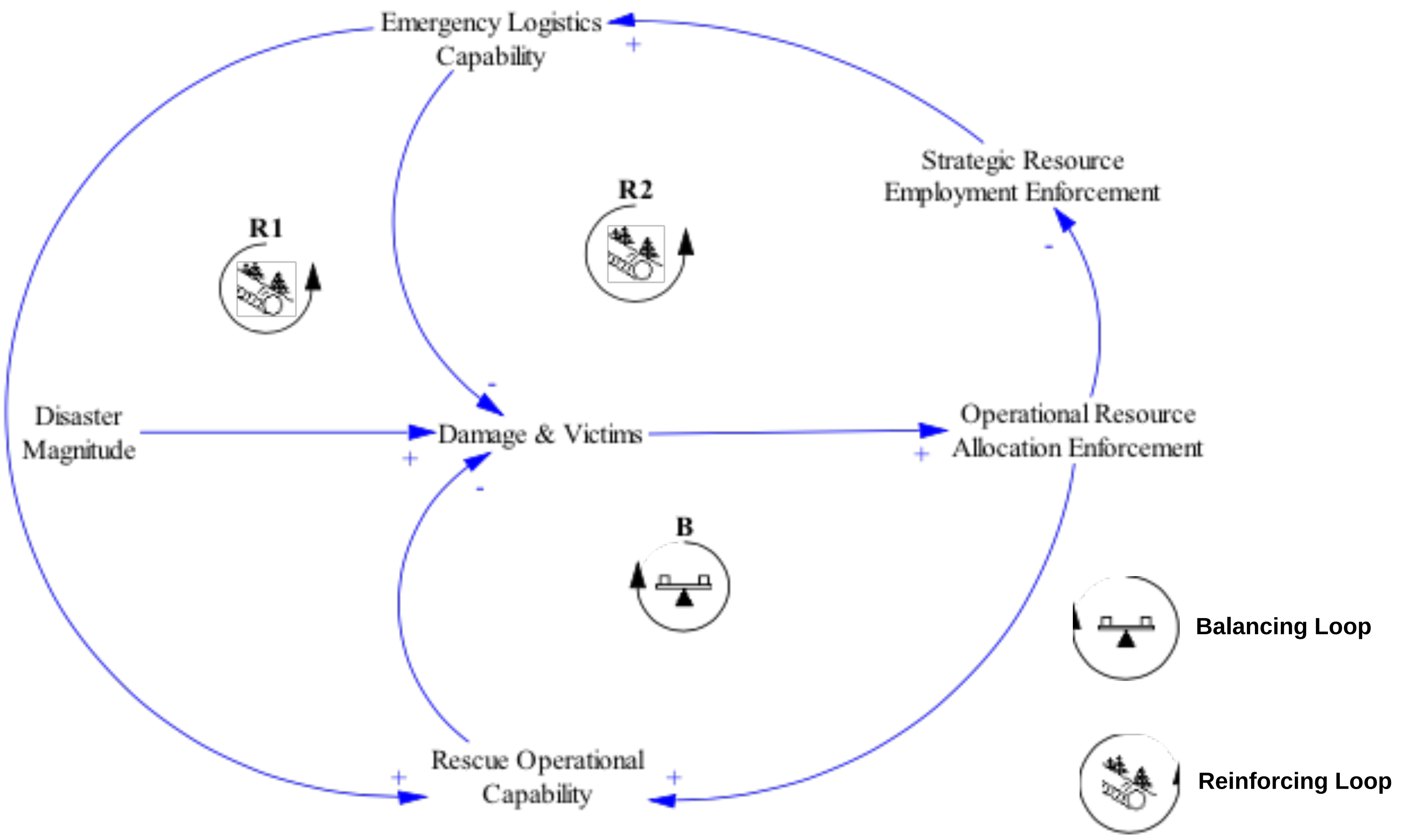
- Assumptions and limitations

- Causal loop diagram
- Stock and flow diagrams

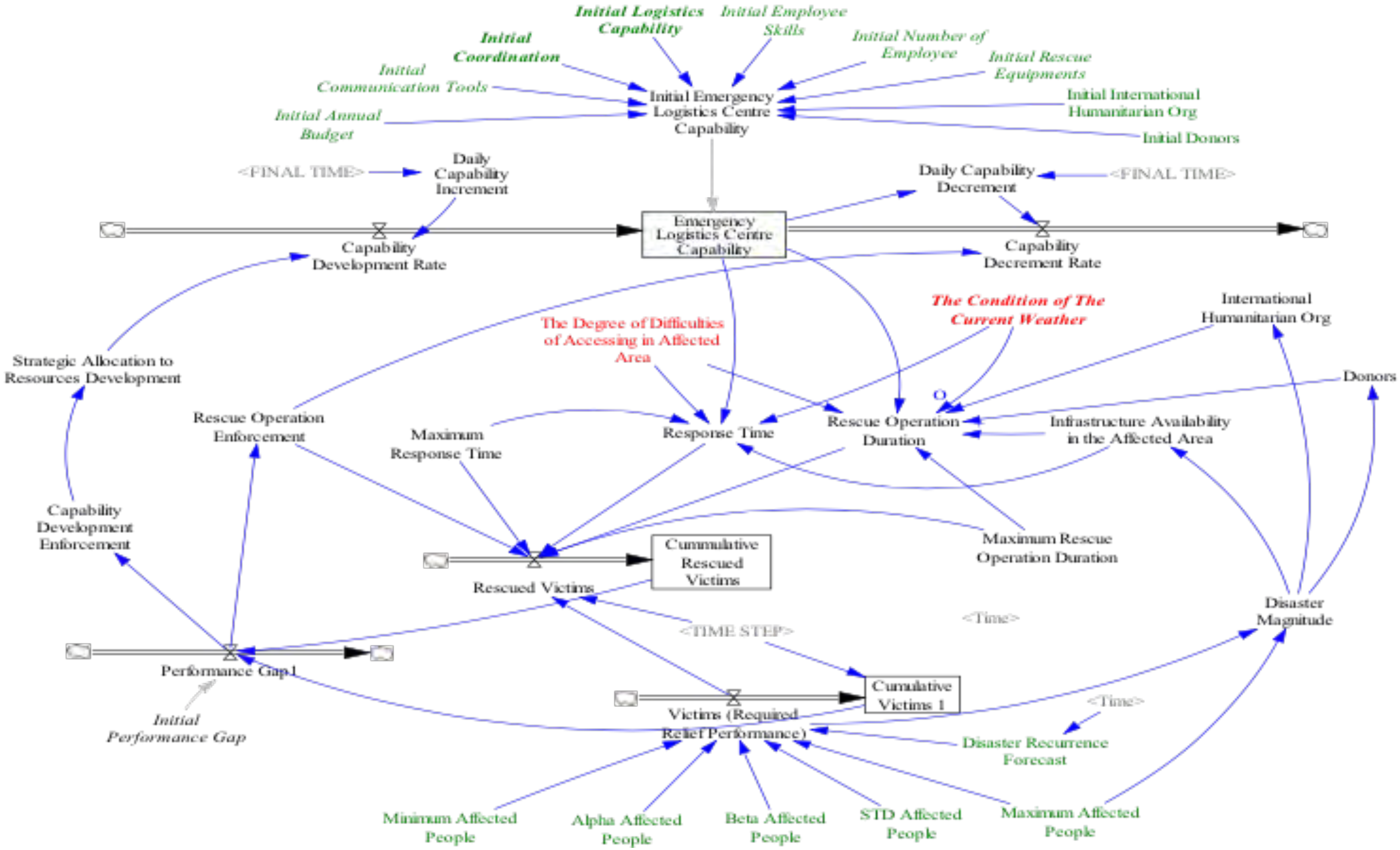
Assumptions and limitations

- choose the timeline for the model to the disaster reoccurrence.
- Availability of materials.
- Budget allocated for relief materials operation by the government.
- Employees involved have the prober skills.
- Limitations on available equipment.
- Limitation on the number of trained employees.

The causal loop diagram



The stock-and-flow diagram



Recommendations from findings

- The research will also include a gap analysis between the benchmark systems for the emergency logistics and the Current Emergency Response systems in the port.

- Does the current system meet the criteria of best practice emergency response system, given the results of the empirical evidence? The findings of this study can be used by emergency response managers in planning for disaster relief operations.

- The expected outcomes will include improved resource application and reduction of duplicated relief response, saving more lives and enhancing the quality of life of survivors.

The Simulation and Results

- Scenario design

- Simulation results

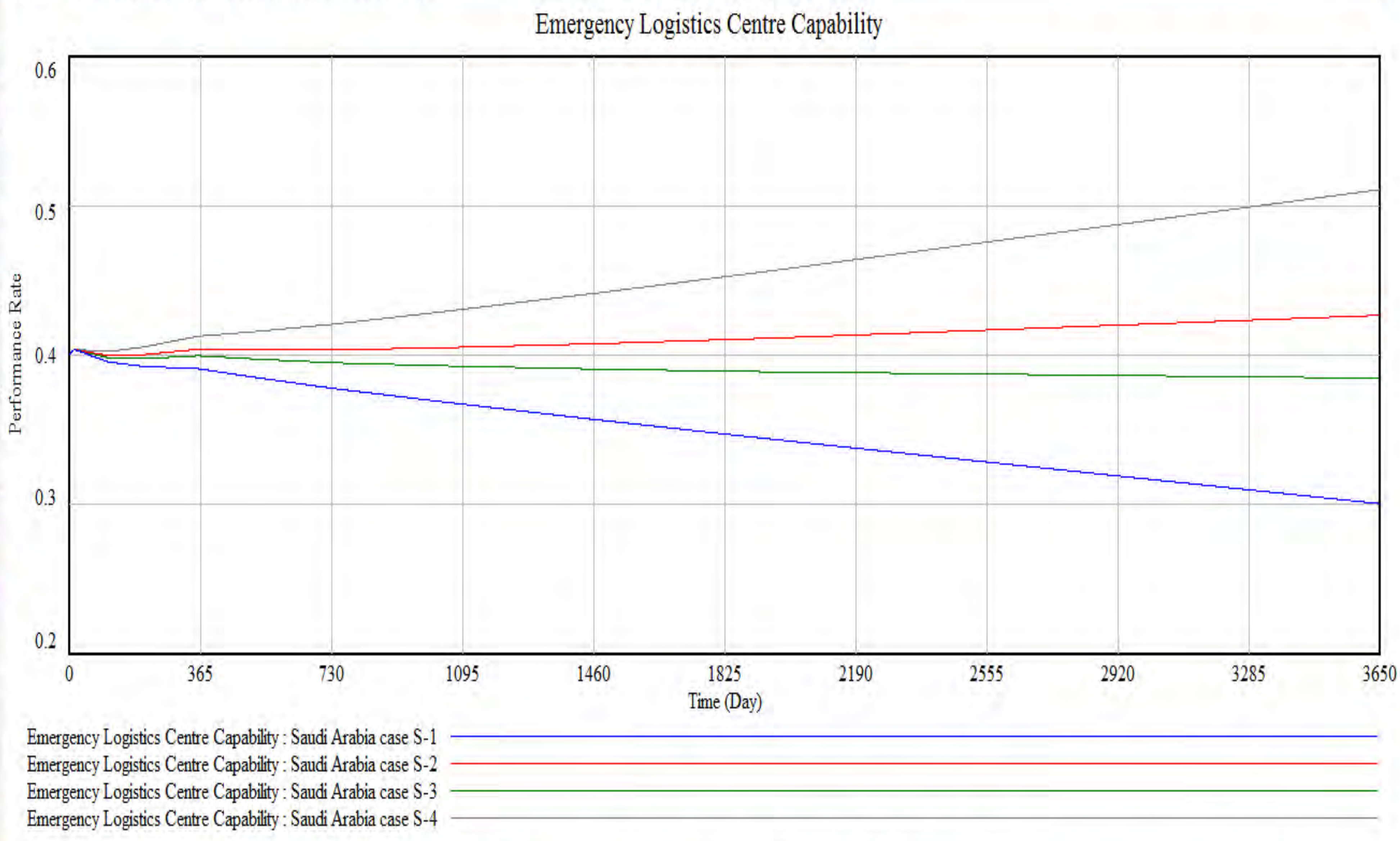
Scenario Design for Simulating Case Study 1 Model

To examine the model, four scenarios were constructed containing three main values A, B & C. Value “A” presents the ten Common **Variables** of/in the model.

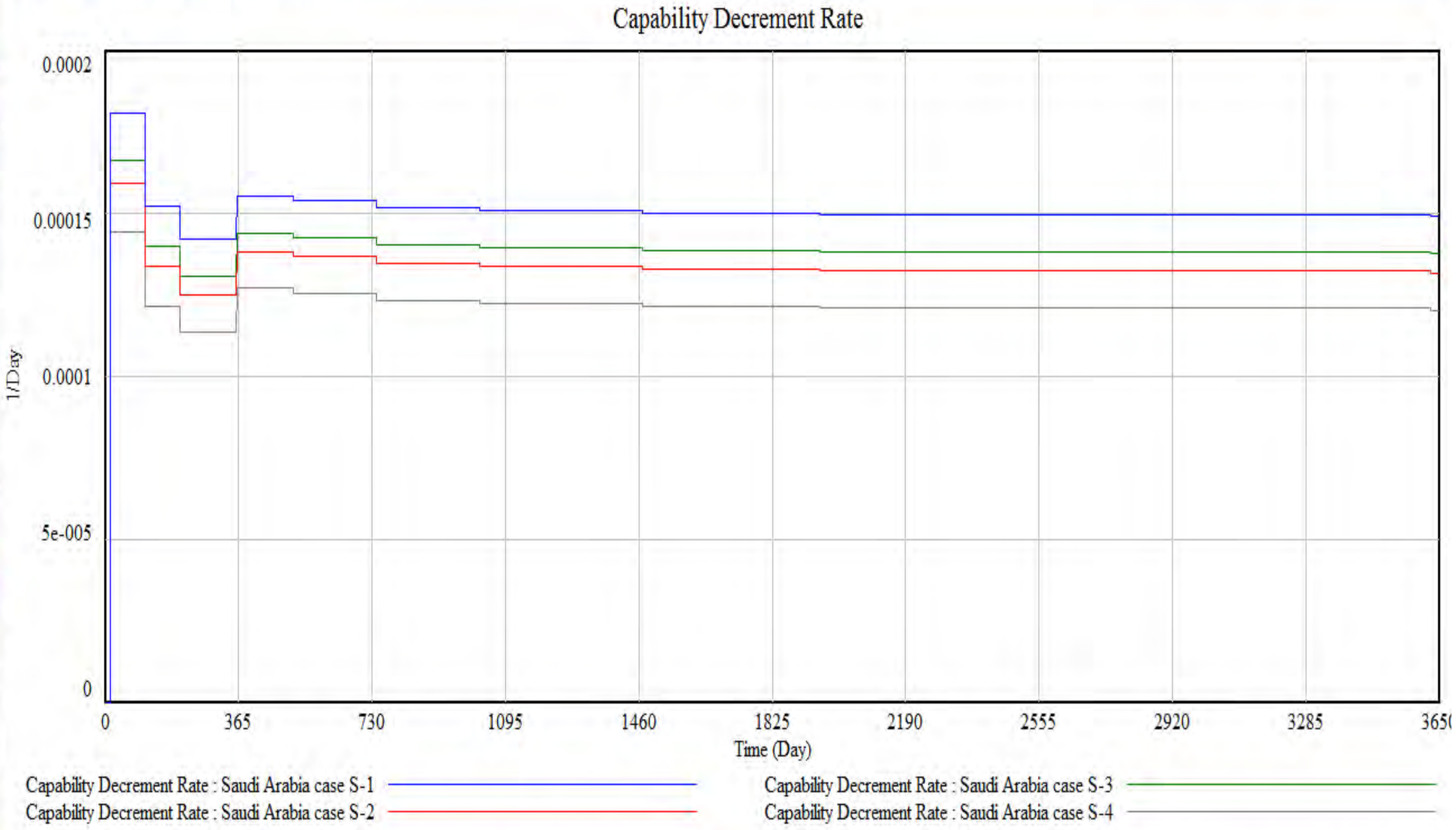
The four scenarios:

- ***S1= (A=0.4, B=0.4, C=0.4)***
- ***S2= (A=0.4, B=0.4, C=0.8)***
- ***S3= (A=0.4, B=0.8, C=0.4)***
- ***S4= (A=0.4, B=0.8, C=0.8)***

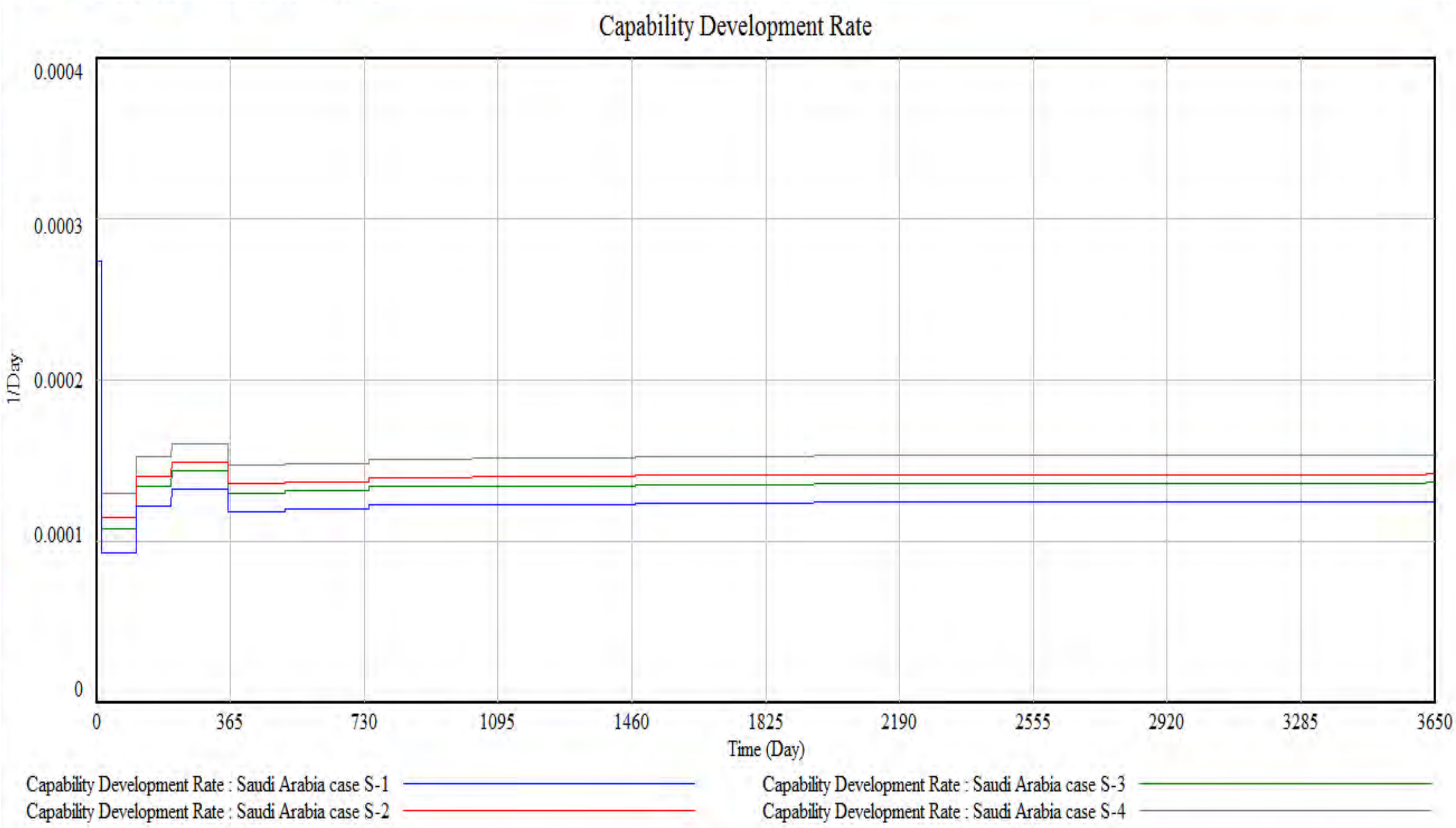
The Simulation results
Emergency Logistics Centre Capability



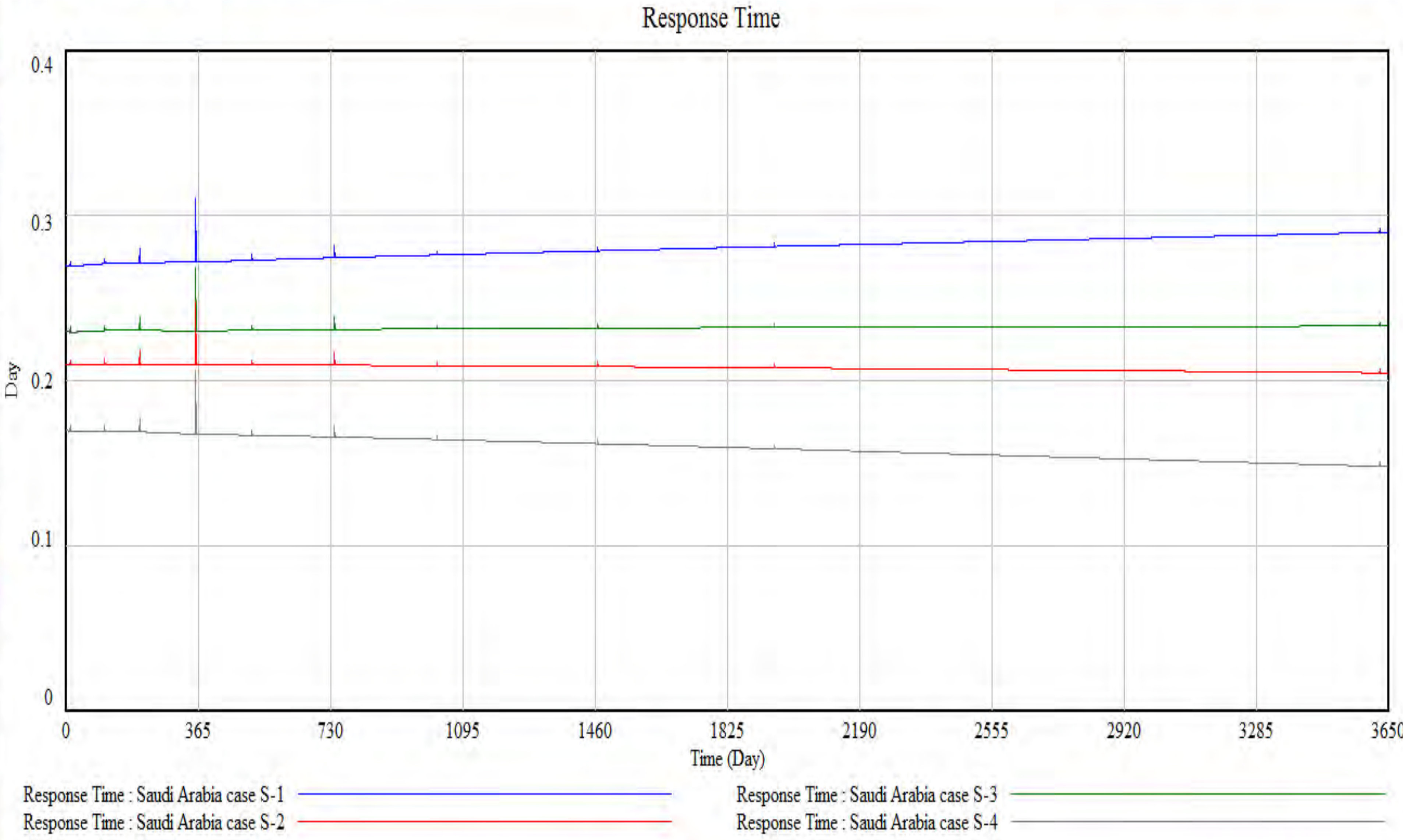
The Simulation results Case Study 1 Model Capability Decrement Rate



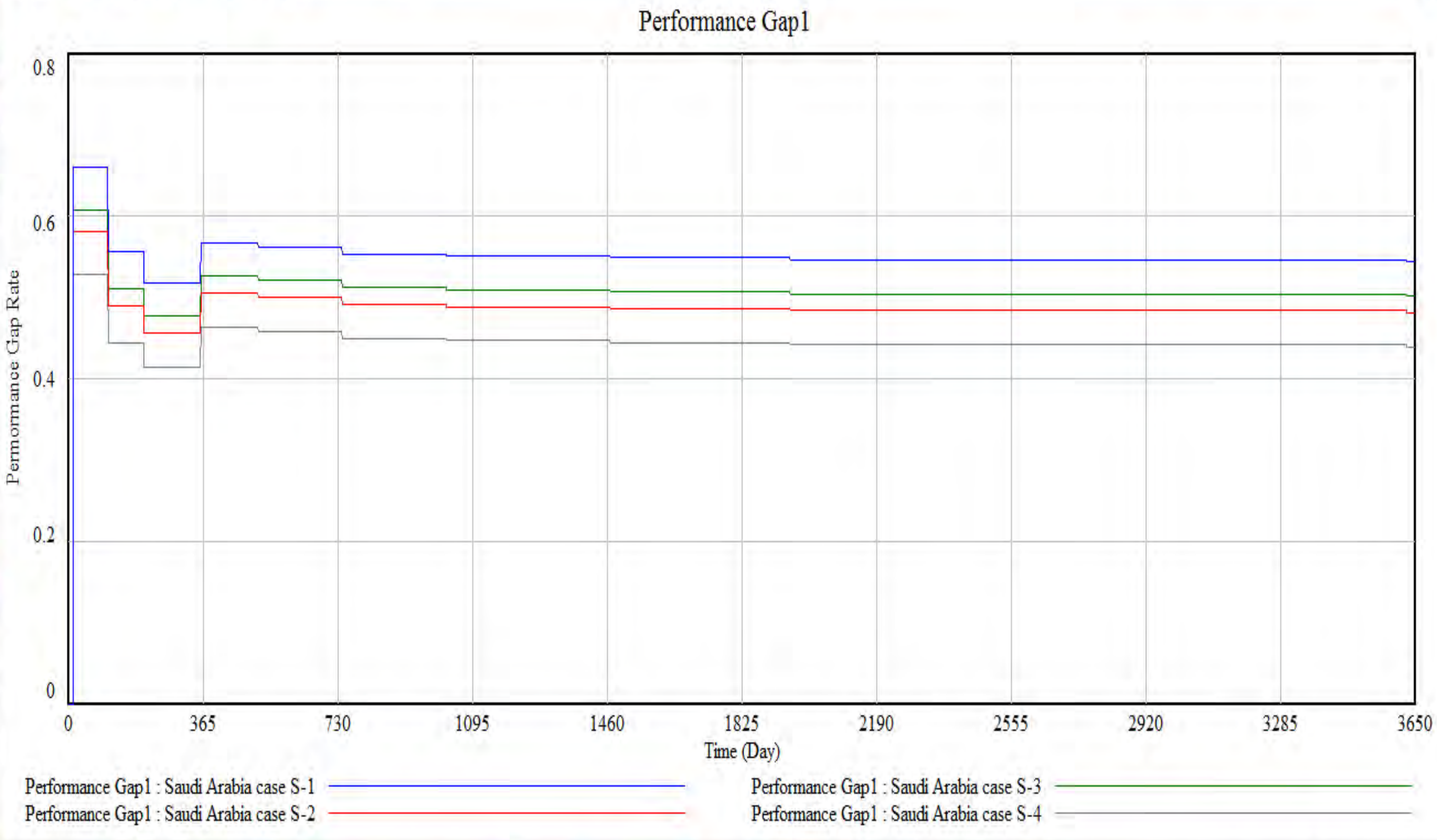
The Simulation results Case Study 1 Model
Capability Development Rate



The Simulation results Case Study 1 Model Response Time



The Simulation results Case Study 1 Model Performance Gap1



Conclusions

- From the modelling process, managers could develop their systems thinking skills allowing them to better grasp the dynamic complexity in humanitarian relief systems

- Modelling the organizational dynamics in specific situations allows better understanding of

a) the behaviours that develop and

b) the potential policies that might be used to improve performance.

- can explore what-if scenarios that would be possible under different strategies, all of which should help them further their understanding of the systems.

Conclusions (cont,)

- Optimal decisions can be made based on the developed model

- Furthermore, having the models at hand, managers gain an appreciation for the consequences of

a) interactions among variables, experience first-hand

b) the long-term side effects of current decisions

- Mapping the model closely to a particular resource allocation challenge would allow managers to see the consequences of their decisions and alternative policies in a familiar

  problem.

THANK YOU

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