A system dynamics approach to study the behavior of Cape Town tourism for the next coming 10 years

Shelly Mona
Industrial Engineering Department
Tshwane University of Technology
Pretoria, South Africa
shellym@nissan.co.za, shellyt.mona@gmail.com

Abstract

Cape Town is a coastal city in South Africa. It is the second most populous urban area after Johannesburg. The city is famous for its harbour, for its natural setting in the Cape Floristic Region, Robben Island, and the beach and for such well-known landmarks as Table Mountain and Cape Point. For this reasons Cape Town shines as a tourist destination. The purpose of this Project is to develop simulation model for Cape Town Tourism using Stella software in order to study the behavior of the system for the next coming 10 years. System dynamics is an approach to understanding the nonlinear behavior of complex systems over time using stock, flows, internal feedback loops, table functions and time delays. The approach that was used was to develop a simulation model is based on the following five stages of system dynamics modeling process: problem articulation, formulation of dynamic hypothesis, formulation of simulation model, testing of the model, and policy design and evaluation. Initial hypothesis was generated based on the research done. The Model study supports the hypothesis; as the population of Cape Town grows without the necessary expansion of services, Cape Town will be less attractive to tourism. Therefore, the number of tourists visiting will decline.

Keywords
System dynamics, Population, Tourism

1. Introduction

Cape Town is a coastal city in South Africa. It is the second most populous urban area after Johannesburg. The city is famous for its harbor, for its natural setting in the Cape Floristic Region, Robben Island, and the beach and for such well-known landmarks as Table Mountain and Cape Point. For this reasons Cape Town shines as tourist destination. As the population of Cape Town grows rapidly, the tourism system may be affected and this may result in a complex systems. System dynamics is a technique used to understanding and modeling the behavior of complex systems over time by allowing us to construct simulations of our own mental models using simulation software's.

The purpose of this Project is to develop simulation model for Cape Town Tourism using Stella software in order to study the behavior of the system for the next coming 10 years.

The main objectives of the project are to:
- Develop a simulation Model for Cape Town tourism on Stella software
- Quantify the model and simulate text and conduct sensitivity analysis and validation.

2. Literature Review

2.1 System dynamics and the modeling process

System dynamics is an academic discipline created in the 1960s by Dr. Jay W. Forrester of the Massachusetts Institute of Technology. System dynamics was originally rooted in the management and engineering sciences but has gradually developed into a tool useful in the analysis of social, economic, physical, chemical, biological, and ecological systems. In the field of system dynamics, a system is defined as a collection of elements that continually interact over time to form a unified whole. The underlying relationships and connections between the components of a system are called the structure of the system. The term dynamics refers to change over time. If something is dynamic, it is constantly changing. A dynamic system is therefore a system in which the variables interact to stimulate changes over time. System dynamics is a methodology used to understand how systems change over time. The way in which the elements or variables composing a system vary over time is referred to as the behavior of the system (Martin, 1997).

The behavior of a system arises from its structure. The six common modes of dynamic behavior are: exponential growth, goal seeking, oscillation, and S-shaped growth, growth with overshoot and overshoot & collapse. Exponential growth arises from positive (self-reinforcing) feedback, the larger the quantity, the greater its net increases, further increasing the quantity and leading to ever-faster growth. Goal seeking rises from negative feedback loop, Negative loops seek balance, equilibrium, and stasis; this loops act to bring the state of the system in line with a goal or desired state, They counteract any disturbances that move the state of the system away from the goal. Oscillations are caused by negative feedback loops with delays, In an oscillatory system, the state of the system constantly overshoots its goal or equilibrium state, reverses, then undershoots, and so on; The overshooting arises from the presence of significant time delays in the negative loop. S-shaped growth-growth is exponential at first, but then gradually slows until the state of the system reaches an equilibrium level; the shape of the curve resembles a stretched-out "S". More complex patterns of behavior such as S-shaped growth, growth with overshoot, and overshoot and collapse result from the nonlinear interaction of these basic feedback structures (Sterman, 2000).

According to Sterman Most systems dynamics models are created from five stages: problem articulation, formulation of dynamic hypothesis, formulation of simulation model, testing of the model, and policy design and evaluation. Problem articulation involves theme selection, identification of key variables, time horizon and dynamic problem definition (reference modes). Formulation of dynamic hypothesis involves initial hypothesis generation (current theories of the problematic behavior), formulating a dynamic hypothesis that explains the dynamics as endogenous consequences of the feedback structure, and mapping which is basically developing maps of casual structure (based on initial hypothesis, key variables, reference modes, and other available data). Formulation of a simulation model involves specification of structure, decision rules, estimation of parameters, behavioral relationships, and initial conditions, and also test for consistency with the purpose and boundary. Testing is basically comparison to reference modes. Policy design and evaluation involves designing of the policy, sensitivity analysis, evaluating the interactions of policies and analyzing the effects of the policies.

In system dynamics we use several diagramming tools to capture the structure of systems, including causal loop diagrams and stock and flow maps. A causal loop diagram (CLD) is a causal diagram that aids in visualizing how different variables in a system are interrelated; the diagram consists of a set of nodes and edges. Nodes represent the variables and edges are the links that represent a connection or a relation between the two variables. Casual loop diagrams are excellent for: Quickly capturing hypotheses about the causes of dynamics, Eliciting and capturing the mental models of individuals or teams, communicating the important feedbacks that are believed to be responsible for a problem. Stocks are the states of the system upon which decisions and actions are based, they are the source of inertia and memory in systems, and they create delays, and generate disequilibrium dynamics by decoupling rates of flow. Stocks accumulate (integrate) their inflows less their outflows. Equivalently, the rate of change of a stock is the total inflow less the total outflow. Thus a stock and flow map corresponds exactly to a system of integral or differential equations (Sterman, 2000).

3. Hypothesis

As the population of Cape Town grows without the necessary expansion of services, Cape Town will be less attractive to tourism.

4. Methodology

The Model was constructed using Stella 10.0.2 Software, and the time horizon of the model is the period of 2015 to 2028. The model was developed based on the following five stages: problem articulation, formulation of dynamic hypothesis, formulation of simulation model, testing of the model, and policy design and evaluation as per (Sterman, 2000). The stock and flow diagram shown in figure 1 presents the tourism model. Firstly Casual loop diagrams were developed to assist in the developing the stock and flow diagram. The model was developed based on primary variables that are believed to have direct interrelationship with the number of tourists visiting Cape Town. The tourism model is depended on both the current population and the carrying capacity. The initial population and tourism values used on the model were both obtained from SA stats.

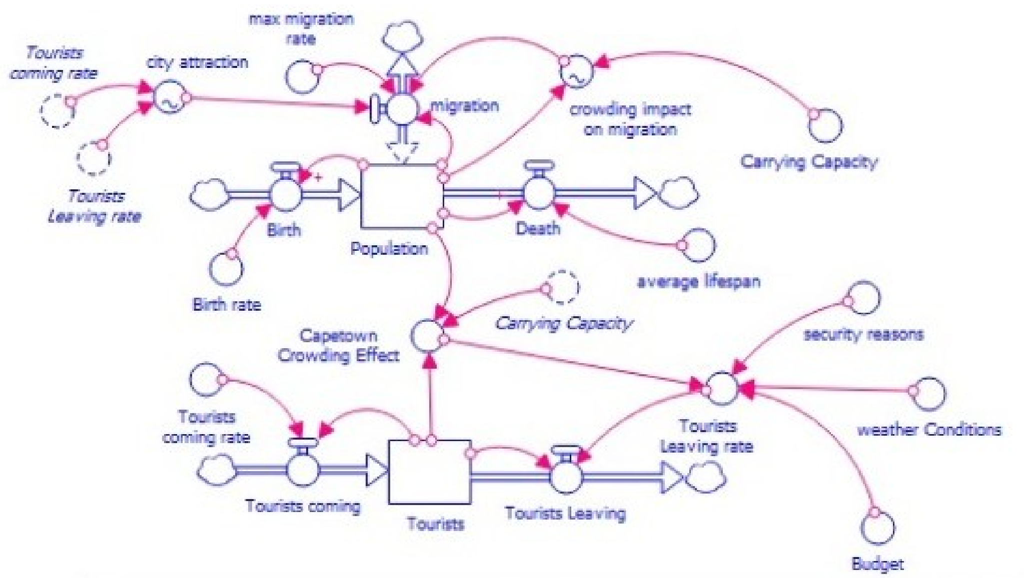

Figure1. Stock and flow diagram

5. Results and discussions

From the simulation results obtained below it can be observed that as the population of Cape Town is growing, the number of tourists coming is declining; meaning as the population of Cape Town grows, Cape Town will be crowded and the destination will not be attractive to tourism anymore; thus resulting in the number of tourists declining.

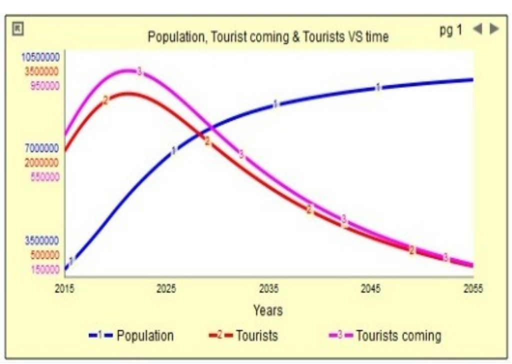

Figure 2. Population, Tourists coming & Tourists VS time

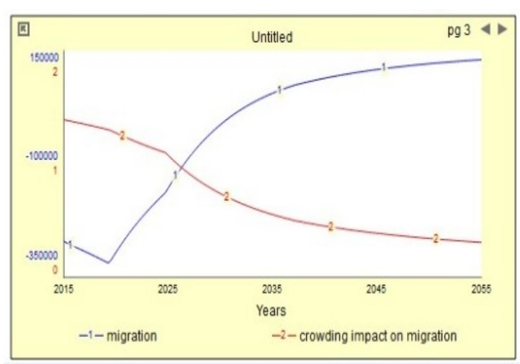

Figure 3. Migration & Crowding impact on migration VS time

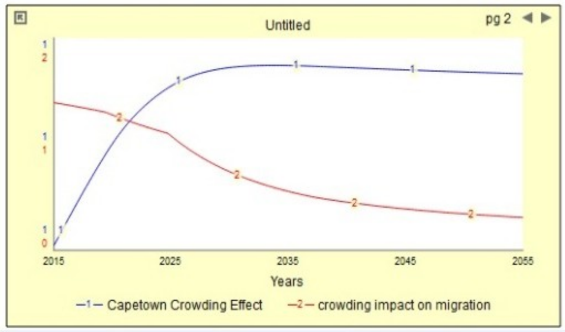

Figure 4. Crowding effect & crowding impact on migration VS time

Table 1. Population and tourists changes

Population and Tourists Changes

	Population	Tourists	migration	Birth	Death
2015	3,740,026	2,167,698	-269,987	112,201	53,429
2016	4,075,842	2,378,916	-282,064	122,275	58,226
2017	4,427,936	2,564,378	-292,617	132,838	63,266
2018	4,796,390	2,716,057	-303,691	143,892	68,520
2019	5,182,004	2,828,120	-315,221	155,460	74,029
2020	5,578,203	2,897,204	-294,553	167,346	79,689
2021	5,949,759	2,924,362	-260,979	178,493	84,997
2022	6,294,765	2,914,626	-230,915	188,643	89,925
2023	6,616,183	2,874,655	-203,954	198,485	94,517
2024	6,916,599	2,809,875	-179,665	207,498	98,909
2025	7,198,160	2,726,064	-152,990	215,945	102,831
2026	7,461,923	2,628,381	-116,960	223,858	106,456
2027	7,675,167	2,522,101	-85,400	230,255	109,646
2028	7,871,760	2,411,502	-57,887	236,153	112,484
2029	8,045,152	2,299,760	-33,972	241,355	114,931
2030	8,198,461	2,189,149	-13,218	245,954	117,121
2031	8,334,382	2,081,237	4,784	250,031	119,063
2032	8,455,266	1,977,068	20,406	253,658	120,790
2033	8,563,142	1,877,242	33,979	256,894	122,331
2034	8,659,750	1,782,134	45,797	259,792	123,711
2035	8,745,582	1,691,871	56,110	262,397	124,951

Table 2.Crowding effect and city attraction changes

Untitled Table

	Capetown Crowding Effect	city attraction	crowding impact on migration
2015	1	1	1
2016	1	1	1
2017	1	1	1
2018	1	1	1
2019	1	1	1
2020	1	1	1
2021	1	0	1
2022	1	0	1
2023	1	0	1
2024	1	0	1
2025	1	0	1
2026	1	0	0
2027	1	0	0
2028	1	0	0
2029	1	0	0
2030	1	0	0
2031	1	0	0
2032	1	0	0
2033	1	0	0
2034	1	0	0
2035	1	0	0

6. Conclusions and Recommendations

This study was aimed at developing a simulation model for Cape Town tourism system, in order to study the behavior of the system for the next coming 10 years. Based on the simulation results; The Model study supports the hypothesis. As the population of Cape Town grows without the necessary expansion of services, Cape Town will be less attractive to tourism, therefore the number of tourists visiting will decline. For similar future studies additional variables (i.e. other factors that affect population growth and also all the factors affecting tourism) that may be linked to the problem of study must added, this can help achieve more precise results.

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Biographies

Shelly Mona is currently an Industrial Engineering master's student at Tshwane University of Technology and a Product Development Engineer at Nissan South Africa. Shelly is also an E-Tutor for Automatic Control at University of South Africa. She holds a bachelor of Technology in Mechanical Engineering, a high certificate in project management from University of Johannesburg and a high certificate in production and operations management from University of South Africa. She worked as a part quality assurance engineer in training at Nissan South Africa. Shelly did her internship with the department of infrastructure development, where she was doing project management under the maintenance section.