System Dynamics Approach for Coastal Nature Conservation:
An example of Sharm El-Sheikhs' Coral Reefs – Sinai – Egypt.

*Mohab Elrefaie**-- elrefaie@yahoo.com

Sylvia Herrmann[a]-- S.Herrmann@iggf.geo.uni-muenchen.de

* Department of Urban Planning, Faculty of Engineering, Ain-Shams University,

4 El-Gaad st. Roxy, Heliopolis – 11341 Cairo-Egypt,

[a] Prof. Dr. Sylvia Herrmann, Department of Geo- and Environmental Sciences, Section Geography,

Ludwig-Maximilian-University Munich, Luisenstr. 37 D – 80333 Munich - Germany

Abstract

This paper describes a detailed computer model developed, for Sharm El-Sheikh city, using Vensim simulation program in system dynamics tradition. This model was created to estimate and compare socio-economic and ecological impacts of different tourism development strategies, in Sharm, from sustainability point of view. An outline of feedback; (cause/effect diagrams) is presented, followed by details of the model boundary and its' simulation structure.

Sharm present development trend was analyzed for a time bounds 1985 – 2002. The model validity is tested based on extrapolation of such present trend of Sharm without any specific policy constrains on land or marine use. Four different development scenarios are generated for a time bounds 2002-2020. Simulation output and scenarios evaluation are then discussed.

The ability of system dynamics to combine the economic, ecological and social aspects of future development might help to create a concept for the sustainable planning of tourism activities in the region.

1. Introduction

In the early 1970s tourism was considered a "smokeless industry" a largely dependent on using and developing the natural and cultural resources of a country as attractions for visitors. Tourism was also looked upon as a panacea for stimulating economic development due to its extensive contribution to foreign exchange earnings, generation of income, employment and government revenue.

According to recent statistics, the environmental impact of tourism development is of serious concern. In some popular destination, the natural attractions of the area have been damaged or destroyed due to overbuilding and irresponsible development overlooking different capacity thresholds of the area. The coastal tourist industry in Egypt is booming, and large expanses have been developed into beach resorts. The most intensively developed area, on the Gulf of Aqaba coast, is Sharm-el-Sheikh. Significant tourist development has also taken place at Dahab, Nuweiba and Taba. It has been reported that area such as Sharm-el-Sheikh has been developed and exploited beyond their ecological and social carrying capacities and is already showing signs of environmental degradation. Evidence of reef degradation due to tourism and other activities is clear even in areas such as the Ras Mohammad National Park (UNEP1997).

The tourism and recreation industry is confronted with serious and difficult choices about its future. The decisions made now would for decades affect the environment, lifestyles and economic opportunity of residents in tourism destination areas. Many of these decisions are irreversible because once communities lose the character that makes them distinctive and attractive to nonresidents, they have lost their ability to vie for tourist-based income in an increasingly global and competitive marketplace.

It is crucial to search for a balance between environment (compatibility) and economic growth (sustainable). Tourism is an important part of this dynamic and the demand for innovative forms of assessment is growing rapidly. This paper takes as its task to address the broad problem of tourism development consequences on eco-system environment. It describes a computer simulation model, developed in the system dynamic tradition, which provides a means of estimating the impacts of various tourism development policies on the coral reefs communities existing in Sharm El-Sheikh coastal zone. However, the purpose of this study is not to identify optimal policies under a central scenario assumed to be correct rather than, it identifies the sources and consequences of the conflict, so that further research may be better targeted and decision makers may become aware of blind spots in current situation.

2. Description of the research area

Since 1982, the time at which Egypt regained her political control over Sinai, the development of the peninsula has become strategically essential. However, Sharm-el-Sheikh started to expand about five years later. The protected area to the south of the city at Ras Mohammed waited six years to be established as a National Park in 1989. Sharm is probably the best-known town of the southern Sinai, for the simple reason that it is the town that gave the Red Sea an international reputation as one of the world's most extraordinary diving destinations. The coral reefs of Ras Mohammed, Tiran and the Aqaba coast, on which Sharm-el-Sheikh built its legendary reputation, are as dazzling as ever. Fig. 1 shows the location of the research area.

Fig. 1 Map of Sharm-el-Sheikh area including National Park Ras Mohammed

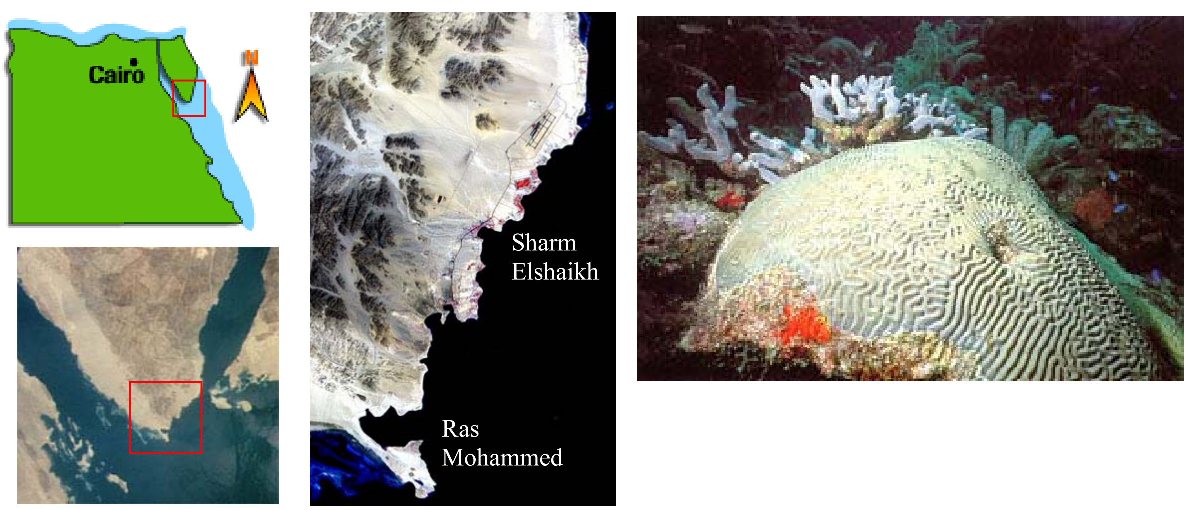


Fig. 1

With growing promotional activities from the Government of Egypt (GOE) and increasing popularity of SCUBA diving in the area, the city's shoreline came under pressure from international and national developers. Accordingly, between 1988 and 1992, the city council sold 100% of the coastline to developers (Salem. S., 1993). The development started by Naama Bay (see Fig. 1) because of the absence of fringing reef along its 1 km sandy beach as well as its close proximity to the airport. It was soon sealed with concrete and the urbanization boom continued along the coast

3. Methodology

3.1 Background

Our specific objectives are twofold. First, we seek to structure an integrated model of Sharm-el-Sheikh where dynamic feedback relations of socio-economic conditions and environmental impacts are simultaneously and consistently incorporated. Second, to use system dynamics simulation to explore such relations to provide seeds for policy thought.

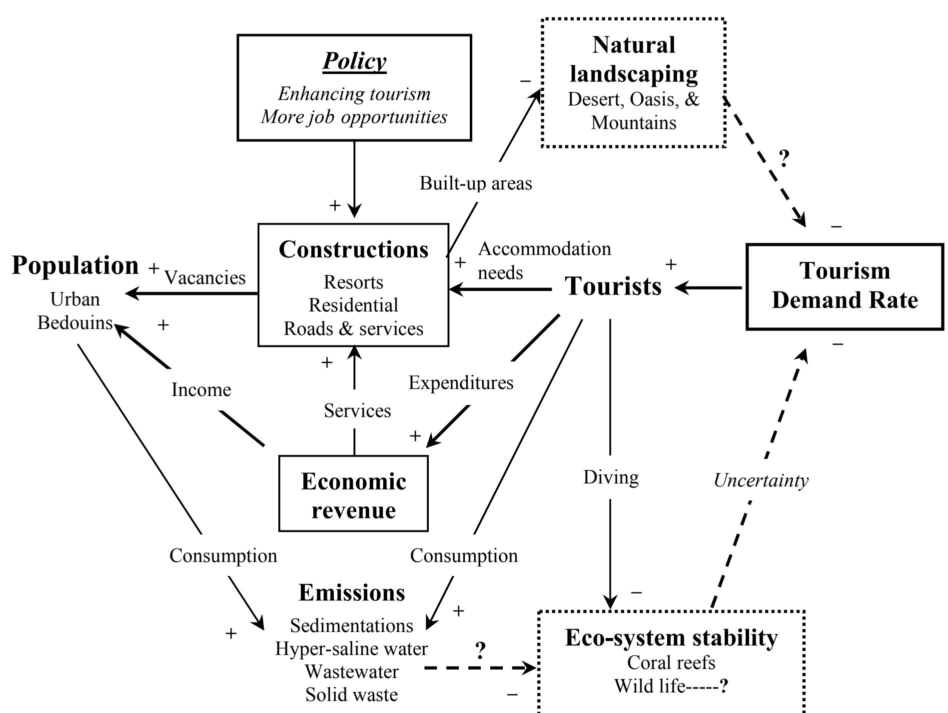
When ecosystem, especially coral-reefs, is of a leading factor for tourism attraction in a region as it is in Sharm-el-Sheikh and the booming construction activities expanding recklessly to accommodate the influx of tourism a degradation of this coral reefs, in a long term period, may happen, which will affect passively the tourism attractiveness of the region on the coming future. Much of the research about diver-caused reef damage suggests there is a carrying capacity for dive sites, above which damage increases drastically. Research in the Red Sea and Caribbean suggests a threshold, which reefs can securely support of 5,000-6,000 dives per site per year. Recreational SCUBA diving causes damage to reefs at exponentially increasing rates as diving intensity increases (Hawkins & Roberts, 1997). Many sites around Sharm-el-Sheikh far exceed that threshold. David Medio and Rupert Ormand, found that coral photographers, eager to get closest to the reef and distracted by their equipment, inflict over two-thirds of the damage, despite accounting for fewer than one-fourth of the dives.

Therefore, the description of the relationship between the economic development (increase of tourism) and the ecological impact (reef's damage) is the central task of the modeling process.

3.2 General Model Structure

For convenience, we present first a simplified view of the overall model, in Fig. 2. Subsequently, we discuss matters of model features, data and measures, and finally, present simulation results.

Fig. 2. Basic structure of the integrated model



(?) Measuring indicator is not available.

3.3 Model components

3.3.1 Modules overview

Four non-spatial modules; compose Sharm integrated model, have been created to simplify problem structure interpretation. (see Fig. 3).

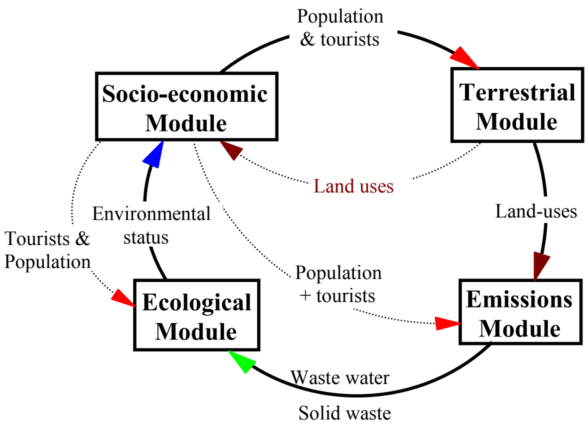


Fig. 3 Modules of the Sharm Model

- **Terrestrial module**: Using tourism demand -side approach the terrestrial module will be used describing different land-use changes. For this five land-use classes have been differentiated: Tourism areas (resorts, hotels, camps etc.), Housing areas, Roads & services, Waste treatment areas, and Desert & natural landscape.

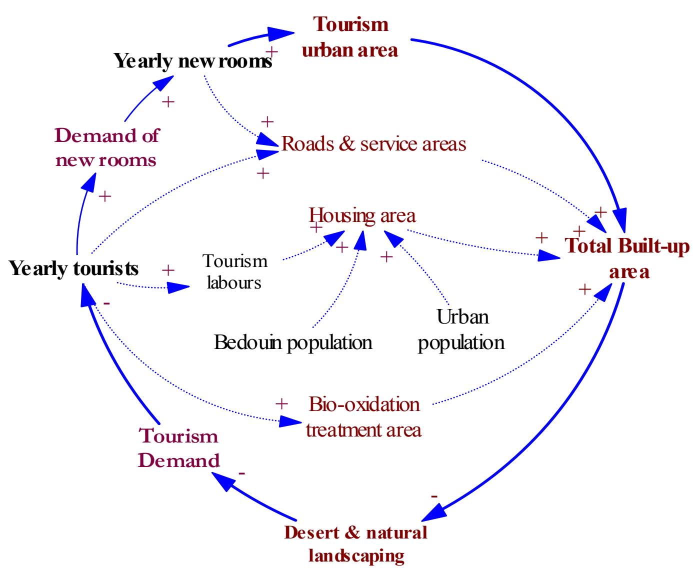
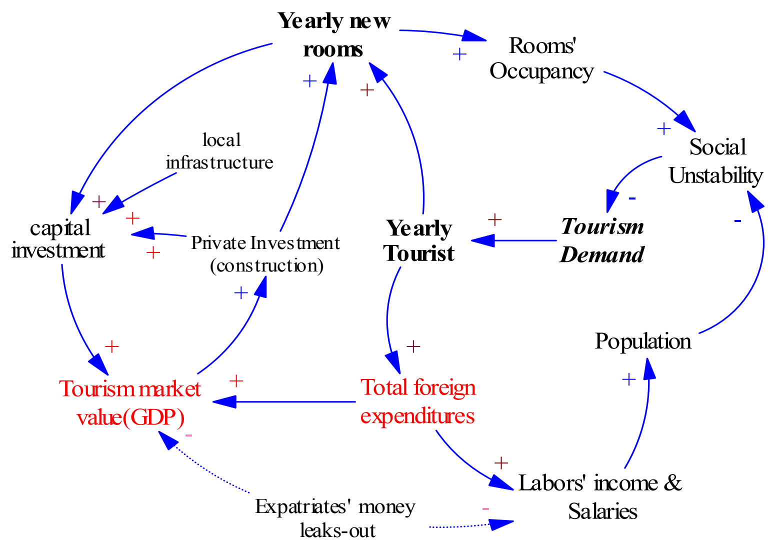


Fig. 4 Diagram of the terrestrial module of Sharm model

- **Socio-Economic module**: The economic module is aimed at simulating the relevant aspects of the socioeconomic reality of our study region where tourism is an important source of foreign currency and a major component of national income. In addition, tourism is a labor-intensive smokeless industry. While there is fairly detailed information on tourists' arrivals, nationalities, and their estimated expenditures, there is limited information on the contribution of this sector to output, employment and income. These shortcomings characterize tourism information and statistics in both Sharm area and the whole Egypt alike.

Fig. 5 Diagram of the socio-economic module of Sharm model



- **Emissions module**: This module is dealing with the amount of waste emitted, wither its hyper-saline water, rejected from desalinate water stations, waste water or solid wastes. Sharm depends, mainly; on desalinate water stations to provide most of the fresh water needed (El Tour water line supplies Sharm, only, with about 2000 m^3/day).

- **Ecological module**: This module is designed, in Sharm model, to calculate the amount, or percentage, of coral reefs, which are susceptible to damages by means of, only, SCUBA diving activity in Sharm area.

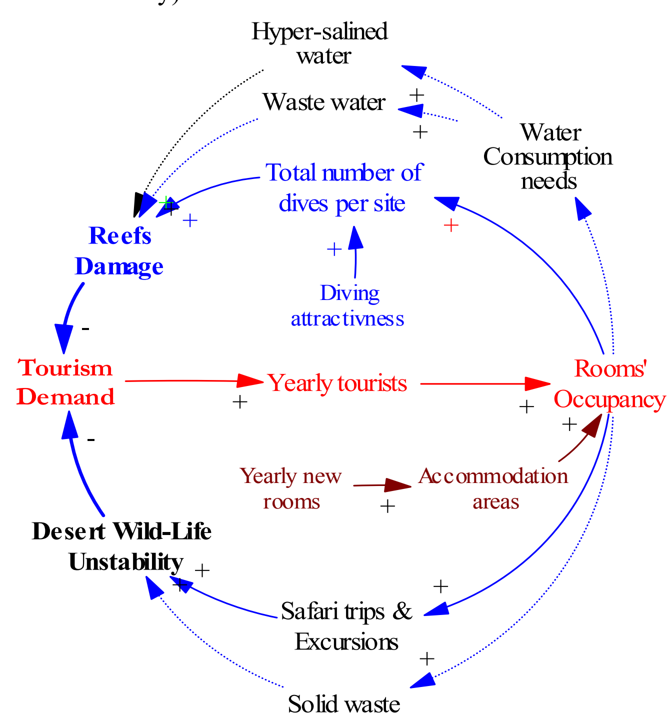


Fig. 6 Structure of Emission-Ecological modules

3.3.2 Model boundary

Several exogenous variables drive the model behavior. Some variables have been omitted, from simulation, because of either data shortage or scarce of impacts indicators' measurements. The variables are listed in table 1.

Endogenous	Exogenous	Excluded Variables and (Links)	*Remarks*
Yearly tourists	Average income	Local expenditures	
Yearly new rooms	Tourist receipt	Export "local goods"	*No Available Data*
Population	Densities	Taxes & operating surplus	
Salary rates	Consumption rates	Areas of sanitary land-filling	
Economic revenue	Waste generation rates	Wild-life stability	
No. Of dives/site/year	Pop-growth rates		
% Of reefs damages	Reefs damage rate	(Natural landscaping _ tourism demand)	
Tourism area	No. Of diving sites		
Housing area	Average stay time	(Hyper-saline water _ reef damage)	*No Impact's Indicator*
Roads & services areas	Beach length	(Bio-Oxidation treatment area _ tourist satisfaction)	
Total urban area			
Desert & natural-landscaping areas			
Beach crowding			
Social density			
Fresh-water needs	Money leaks-out rate*		
Hyper-saline water	Demand decay rate*		** =Uncertainty Data*
Waste water	Diving attractiveness*		
Solid waste			
Rooms occupancy			

Table 1. Variables of the modeling system

3.4 Simulation Design

3.4.1 Methodology

1. The dynamic simulation modeling language of VENSIM software (Ventana Systems, 1995, 1996) has been used for modeling and simulating Sharm behavior.
2. Using VENSIM for each module, the stock-flow diagram has been constructed, and followed by the cause-effect analysis among module parameters.
3. The four modules have been aggregated to form what is called Sharm Simulation Model (SHASIMO)
4. Estimating parameters' values by studying previous Sharm 1985-2002 development present trend using regression analysis.

5. Running the model for 1985-2002, to confirm the dynamic hypothesis (simulation result should match the collected data for Sharm of this time bounds “reference Mode”).

6. Conducting sensitivity analysis (running the model several times with variations in the parameter values, to learn if the basic pattern of results is “sensitive” to changes in the uncertain parameters. Checking, have we got the reference mode after each test, if yes; this will discover that we have a robust model).

This system will be used to project the future socioeconomic-environmental consequences of different scenarios of Sharm El-Sheikh development within a time - horizon (2002–2020). Therefore, the different modules were connected in a modeling complex (see fig. 7).

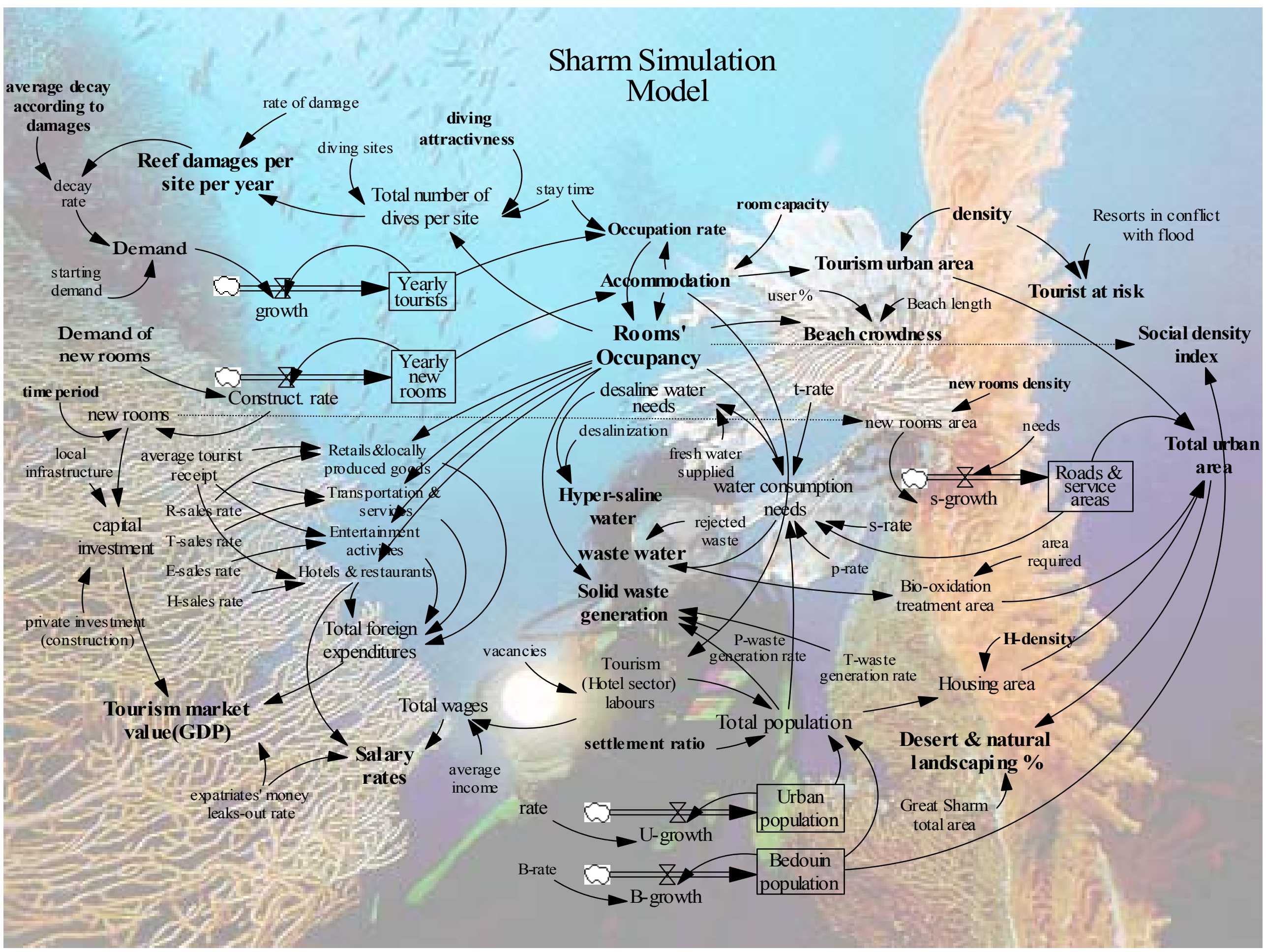


Fig. 7 SHASIMO –complex simulation model of Sharm-el-Sheikh

4. Results of SHASIMO

4.1 Validation of Model and Calculations for 1985 – 2002

- From studying Sharm development trend starting from 1985 it's shown that the tourism demand within the period 1985 -1997 was 21.75%. This combined with a yearly rate of new rooms construction equals to 28% with rooms' occupancy of 68%. Along with this rates, by running the Model, Sharm number of rooms was calculated to be 3868 room in 1997 (3825 rooms was the measured number in 97). According to the 85-97 trends, SHASIMO has calculated, almost, the same number of yearly tourist as the measured one in 1997; 385829 tourists.
- Along with 85-97 trends Sharm rooms were expected to reach 10384 rooms by the end of 2001, but this number is faraway from the existing measured one; (20754 existing rooms in 2001 in Sharm)
- Difference, in number of rooms, between SHASIMO and the reality, period 97-2002, is coming from that SHASIMO is projecting number of rooms according to the previous 85-97 trend; tourism demand was 21,75% and the demand of new rooms was 28% and this trend has been changed dramatically through last five years; 1997 – 2002.
- 97-2002 trend shows an increase in rooms constructing demand rate to reach 51% along-with an increase in tourism demand equals to 32.5%. This rise made rooms' occupancy to decline to reach 25%. This reflects the main problem in Sharm El-Sheikh; where decisions regarding allocating lands for new tourism settlements and constructing new buildings and resorts, are guided, much more, by local economic aspects more than by tourism demand rates or sustainable development margins.

Table 2, shows measured, calculated date and trend consequences.

	1985	1997	***85-97 yearly growth***	2001	2002	***97-2002 yearly growth***
Tourists	37000	385000	*21.75%*	1155000	1500000	*32.5%*
Rooms	200	3825	*28%*	20754	31000	*51%*
Occupancy rate		68%		31%	25%	
Urban Population	1400	6400	*13.6%*	11039	12619	*13.6%*
Bedouins	500	1600	*10%*	2330	2572	*10%*
Model results (run 85 – 2002)						
Reefs damages	0.4%	5%		8%	9%	
Beach density (t/m)	0.02	0.2		0.6	0.8	
Social index (t/Bedouin)	1	3.3		7	8	
Economic revenue (mill $)	16	198		1245	1892	

Table 2. Sharm Previous trend and status-quo 1985 – 2002

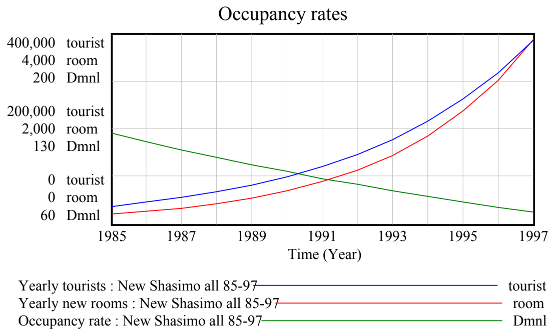


Fig. 8

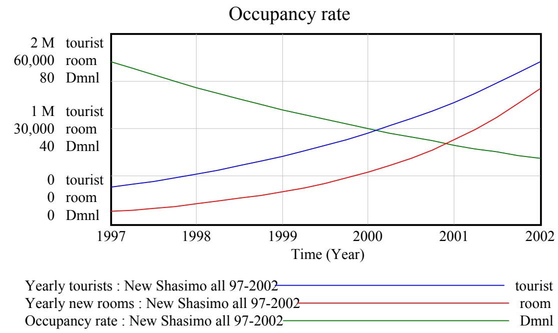


Fig. 9

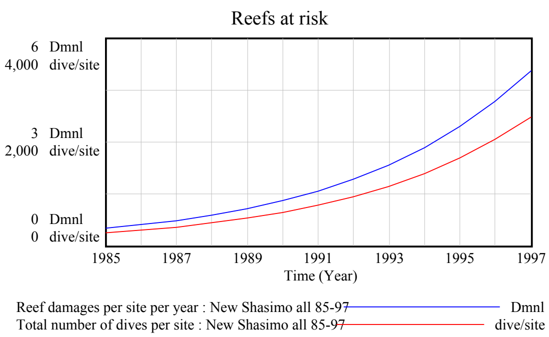


Fig. 10

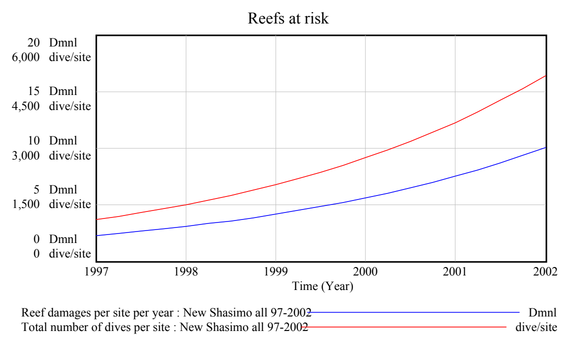


Fig. 11

- More tourists cause more diving activities in Sharm diving sites which rise damage susceptibility to coral-reefs. To a certain limit of reefs degradation, tourists' growth rate will start to decline according to the decrease of tourism demand which is affected by the eco-system situation of the area.
- If the development trend, in Sharm, sustain like the (97-2002) trend the area will face a severe problems concerning environmental and social aspects. Tourists' growth rate, for example, will decline by 2006 where 60% of Sharm reefs will be damaged and occupancy rate will decrease to 5%. Fig. 12 interprets such consequences.

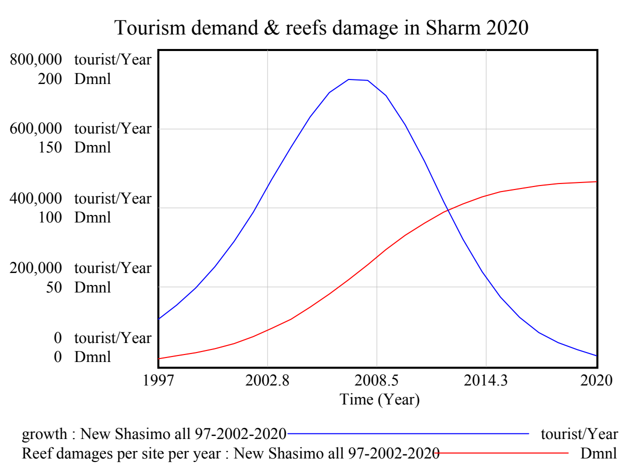


Fig. 12

4.2 Scenarios generation

Impacts of different Sharm development policies (scenarios) were tested within a time bounds started at 2002 till 2020. For that four different scenarios have been generated:

- **Business As Usual (BAU)** scenario: (Sharm development will continue as the same as present trend).
- **Government of Egypt (GOE) Proposal**: (applying values, proposed in Sharm Master Plan for 2017, on different model parameters).
- **Construction Limited Growth (CLG)** scenario: (new rooms construction in Sharm will be banned).
- **Maximizing Occupancy - Minimizing Damages (MOMD)** scenario (trial to optimize environmental and economic benefits**).**

Table 3 shows the assumptions beyond each scenario, targets, and the calculations for Sharm tourism situation in 2020.

Scenario	Business as usual **BAU**	Government of Egypt plane 2017 **GOE**	Construction Limited Growth **CLG**	Maximizing Occupancies Minimizing Damages **MOMD**
Assumptions	1. Total area to be used for future tourism development in Sharm= **9435 acre** (5435 GOE + 40% of 10000 *from GIS suitability analysis*). 2. Expected Nr. rooms by 2020 = **70000** (**30000** existing 02 + **40000** new; density= 4.25 room/acre).	1. With density of 4.25 room/acre and 5435 acre allocated for future tourism development in Sharm by GOE proposal, **23000** room will be added to Sharm by 2020. 2. Total Nr. rooms= **53000** room by 2020.	1. **No more rooms** will be constructed by the beginning of 2003.	1. Values of existing new rooms construction and demand rates will be changed to **optimize Environmental (Coral reefs) and Economic benefits.** 2. Target amount of rooms by 2020 is out of assumption considerations.
Target	Reaching **70000** rooms in Sharm by 2020 with maximum rooms occupation.	Reaching **53000** room in Sharm by 2020 with maximum rooms occupation.	Existing Nr. rooms in Sharm will sustain, till 2020, at **30000** room with maximum Occupation rate	Maximum rooms occupancy and Minimum reef damage to be reached in 2020.
Processing Method	*Running SHASIMO 02-2020 yield:* 1. 70000 room in 2020 by decreasing present construction rate from **51%** to **5%**. 2. Max. Rooms occupancy will be reached in **2007= 99%** with the existing tourism demand rate of **32,5%** and Nr. rooms will be = **38288** room. 3. At this point tourism demand curve will fall down to follow new room's construction rate, which is 5%. 4. By 2020 **90%** of 70000 rooms in Sharm will be occupied by **9,490000** tourist.	*Running SHASIMO 02-2020 yield:* 1. 53000 room in 2020 by decreasing present construction rate from **51%** to **3.3%**. 2. Max. Rooms occupancy will be reached in **2007= 100%** with tourism demand rate of **32,5%** and Nr. rooms= **35287** room. 3. At this point tourism demand curve will fall down to follow new room's construction rate, to be **3%**. 4. By 2020 **98%** of 53000 rooms in Sharm will be occupied by **7,772000** tourist.	*Running SHASIMO 02-2020 yield:* 1. Max. Rooms occupancy will be reached in mid of **2005= 95.6%** with tourism demand rate of **32,5%** and Nr. tourists= **4,195 000** tourist. 2. This amount of tourists will continue constantly from mid of 2005 till 2020; demand rate≤ **0.0%**, as if there are no more rooms to accommodate more increase of demand.	*Running SHASIMO 02-2020 yield:* Optimized situation will be reached in 2020 by: 1. **7%,** instead of **32.5%**, tourism demands which, leads to **4,680000** tourists by 2020. 2. **1%**, instead of **51%**, **new** rooms construction rate, which leads to **35908** rooms by 2020 with occupancy rate of **91.5%**.

Table 3. Overview of assumptions, targets and calculations for each scenario

4.3 Scenario evaluation

To evaluate the consequences (effects) of a scenario, from sustainability point of view, an evaluation criterion has been established. Each scenario has effects on the socio-economic and ecological development of Sharm-el-Sheikh; these effects comprise the basic notion of the policy evaluation criteria. (Suitability analysis has been conducted, by using GIS, to define criterion property, which has spatial aspects like construction suitability, sand-beach availability, marine and land pollution, and land-uses allover different areas of Sharm).

The classification of each of the scenarios effect is shown at the next table (table 4), and a threshold index has been conducted to each indicator. Table 5 shows impacts evaluation of each scenario on a different criterion.

Scenario / Indicator & threshold	Business as usual **BAU**	Government of Egypt plane 2017 **GOE**	Construction Limited Growth **CLG**	Maximizing Occupation Minimizing Damages **MOMD**
Dive/site/year **(Max. 6000-7000)**	13557	11000	5986	6500
Beach crow dness **(max.3.5)**	4.7	3.9	2.1	2.4
Water needs (Network capacity= **28500 m3/day)**	100000	87000	80903	85000
Waste water (Network capacity= **30000 m3/day)**	82000	69603	64722	68000
Economic revenue (+)	3,428 000 bill. $	2,734 000 bill. $	1,414 000 bill. $	1,646 000 bill. $
Social stability index (Max. 3 tourist /Bedouin)	14	12	3.8	4.3

Table 4. Indicators of impact for the different scenarios

The comparison shows that scenario BAU and GOE result in a considerable exceeding of the thresholds for dives/site/year, beach crowd-ness, water needs and waste water production as well as for the social stability index. On the other hand, the economic revenues are by far the highest. Opposite to these findings the other both scenarios are within the limits of value for dives/site/year, beach crowd-ness and close to the one for social stability. The very restrictive scenario CLG meets also the other ecological thresholds, but shows the lowest economic revenue which is only 41% resp. 52% of the first two scenarios. Scenario MOMD shows a slightly better economic result but is exceeding the limits for water use, waste water production and social stability due to the high number of tourists.

Next, after criteria set-up, information about the relative importance of the criteria will be required. This is usually achieved by assigning to each criterion a **weight** that indicates the criterion importance relative to the other criteria under consideration. Because of this weighting task can’t be handled by System Dynamics, Multi-Criteria Decision Analysis has been used to assign weights, generate score Matrix, and rank scenarios according to specified decision rule.

Criteria	Business as usual **BAU**	Government of Egypt plane 2017 **GOE**	Construction Limited Growth **CLG**	Maximizing Occupation Minimizing Damages **MOMD**
Eco-system stability	**1**	**1**	**2**	**2**
Tourist satisfaction	**1**	**2**	**3**	**3**
Economic revenue	**3**	**2**	**1**	**1**
Supporting Infra-capacity	**1**	**1**	**2**	**1**
Social stability	**1**	**1**	**2**	**2**

Table 5. (1=Low, 2=Medium, 3=High)

5. Scenarios' evaluation results:

According to the previous evaluation it's clear that stopping construction, CLG scenario, is the easiest way to secure the environment; (coral-reefs), sustaining within the existing capacity of infrastructure networks in Sharm, and assuring tourists satisfaction and social stability. However, this may not be the optimal policy for the future tourism development of Sharm where new lands for future tourism are already allocated and sold to the investors. Precise data concerns expected number of new constructed rooms is not available. For this, policy of managing new rooms construction concerning its amount and spatial distribution, within sustainability framework may be more plausible than banning construction in Sharm areas.

Gazing at the CLG and MOMD scenarios' consequences, see Figs. 13-17, one can define only slight differences between the two. The more estimated stressing pressure on water and drainage network by MOMD can be overcome by increasing networks capacity and/or imposing measures to eliminate water consumption.

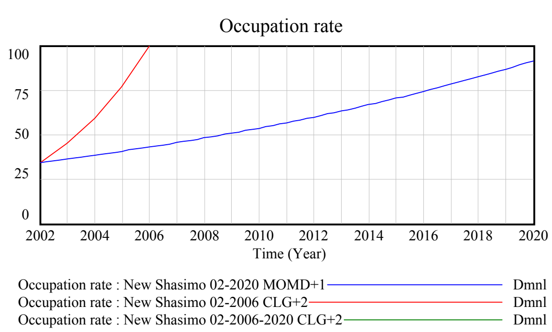


Fig. 13

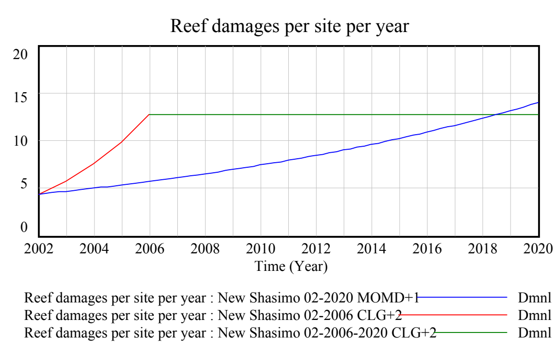


Fig. 14

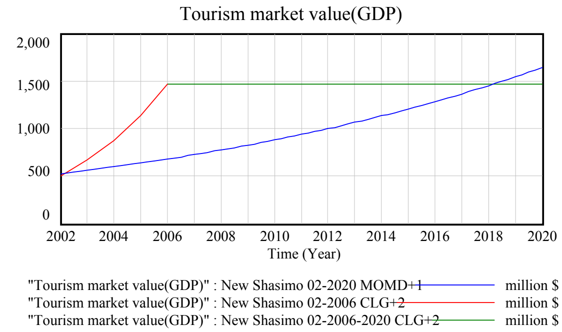


Fig. 15

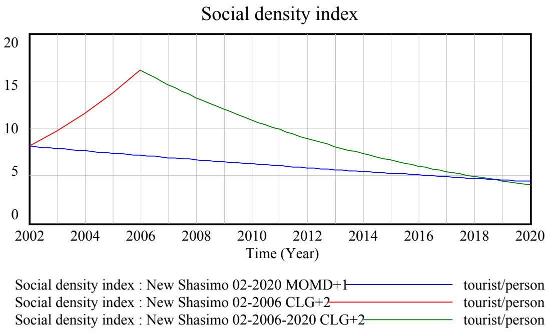


Fig. 16

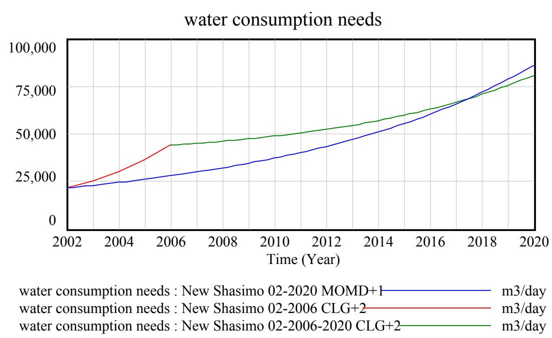


Fig. 17

Because of such slight differences, MOMD scenario can be taken as a suitable scenario for sustainable tourism development in Sharm El-Sheikh. Based on this scenario, as mentioned in table 3, number of rooms in Sharm will reach 35908 rooms by 2020 (about 6000 room, only, will be allowed to be constructed within the period 2003-2020). This is not, of course, the only measure to be taken for Sharm sustainability development other measures should be imposed to regulate or direct the socio-economic up-stream needs that yield down-stream sustainability outcomes.

6. Discussion

With the completion of the first version of SHAISMO the description of important economic, ecological and social relationships in the tourism industry of Sharm-el-Sheikh is possible. Due to a lack of data and/or knowledge, not all components could have been based on exact scientific information. Nevertheless, a first step is made that already offers a good tool to, at least, sketch future developments under certain assumptions. *By 2020, Sharm Marine Eco-system (Coral Reefs) will face severe damage problems and rooms' occupation will reach extreme low rates if the present development trend continues as it is. Infrastructure networks shall be under stress. Although the economic revenue will reach high amounts, welfare distribution of such benefits is not achieved among target group; not sustainable economy (salary rates will decrease because of fixed rate of incomes).* The first calculations show a good coincidence with the available data for the development in the past and so it was possible to evaluate the system. *As mentioned before, between 1988 and 1992 the city council of Sharm has sold 100% of Sharm, 25 km, coast line, which made the total urban area of Sharm reaches, by the end of 1990, 579 acre and increased to reach 1,648 acre in 1997. SHASIMO calculation for the total area in 1997 was, almost the same (1,594 acre).*

These runs also demonstrate that it is very difficult to deal with sudden, unexpected changes in the trends (see change from 85-97 to 97-2002). The use of scenarios seems, therefore, to be a better way to "explore the future". The available scenario runs give an impression how the tool might be used in the future

The ability of the system to combine the economic, ecological and social aspects of future development might help to create a concept for the sustainable planning of tourism activities in the region. Only the application of a system dynamics approach allowed for the structuring of the extremely complex intertwining existing between these aspects. Additionally, the combination of the non-spatial modeling system with the GIS made a spatially explicit relation to the Sharm region possible.

The use of a Multi-criteria-decision approach gives the capability to use the tool for planning decisions. The inclusion of valuation and the ranking of certain preferable choices is an important pre-condition for the policy support.

The current prototype version of SHASIMO needs further improvements. Database concerning diving attractiveness, précised reefs damage rate and its impact on tourism demand should be enhanced. Impacts' indicator measures of some relevant factors like the relation between the decrease of natural landscaping areas and its impact on tourism demand rate, needs to be found. Profound surveys regarding social module e.g. *Social index threshold* should be conducted.

6. References

- Elrefaie, M. & S. Herrmann. 2003. *Coupling of GIS and system dynamics modelling for integrated development of tourist areas.* Ecological Modelling (in prep.)
- Herrmann, S.; Elrefaie, M.; Schwarz-von Raumer, H. & G. Kaule. 2003. *Future Development of Tourism in Sharm-el-Sheikh- Sinai- Egypt: Sustainability assessment based on Spatio-Temporal modelling approach.* Journal of Environmental Management and Planning (in prep.)
- Ventana Systems. 1995. *Vensim User's Guide*. Ventana Systems, Inc., 149 Waverley Street, Belmont, MA 02178.
- Ventana Systems. 1996. *Vensim Personal Learning Edition, User's Guide*. Ventana Systems, Inc., 149 Waverley Street, Belmont, MA 02178.
- Colombia University, School of International and Public Affairs. 1996. *Protecting Coral reefs in Aqaba: An Analysis of Biological, Economic and Political Values*. Environmental policy studies, working paper # 1.
- Hawkins, Julie P. and Roberts M. 1997. *Estimating the Carrying Capacity of Coral Reefs for SCUBA Diving.* Proceeding of the eighth international coral reef symposium, Panama 2 (P. 1923- 1926)
- Michael Paryente et al. 1996 & 1999. *A Comparative Study of the Impact of SCUBA Divers on the Coral Reefs of Eilate, Israel*. Follow-up research to the 1996 study by David Zakai.
- Osama S. Salem. 1993. *GIS for Environmental Planning and Impact Assessment of Sharm El-Sheikh City Sinai, Egypt.* M. Phil thesis, University of Cambridge, UK.
- Ministry of Housing, Infrastructure and New Urban Communities. 1997. *Sharm El-Sheikh City. General Planning for 2017.* Public Authority of Urban Planning, Arab Republic of Egypt.
- Office of Environmental and Social Development. 1996. *Economic Evaluation of Environmental Impacts.* Parts 1 &2, Asian Development Bank, Manila, Philippines.