Use of System Dynamics and Modelling in Tourism

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Abstract
Tourism is a complex system with certain structural and behavioural properties. Problems in tourism are defined softly and solutions require proper methodology. In this paper, methods of system dynamics and system thinking as well as system dynamics models will be discussed. The importance of modelling, which depends on an organisational problem and participants' experiences, will be shown. A causal loop diagram of a tourism system as a part of national strategy will be developed as well as simplified causal loop diagram from the point of view of national tourism market development. A connection between qualitative and quantitative models will be restored.
Keywords: systems, system dynamics, modelling, causal-loop diagrams, tourism,

1 Introduction

The success or failure of a particular policy initiative or strategic plan is largely dependent on whether the decision maker truly understands the interaction and complexity of the system he or she is trying to influence. Considering the size and complexity of the systems that public and private sector decision makers must manage, it is not surprising that the "intuitive" or "common sense" approach to policy design often falls short of, or is counter-productive to, desired outcomes. Tourism is a relatively recent socio-economic activity, encompassing a large variety of economic sectors, players and academic disciplines. Researchers, who have estimated the economic effects of tourism on regional and national economies, modelled tourism as an exogenous activity (Alavapati and Adamovicz, 2000). The complexity of its composition makes it inherently difficult to develop universally acceptable definitions, which would help to describe it conceptually.

Turbulence in the global market is demanding flexibility and fast reaction times from the entire service industry's. It requires decisions, frequently reflecting conflicting interests. Thus, an excellent methodological approach to these problems is urgently needed. Since Ludwig von Bertalanffy published his manifesto of general systems theory (Bertalanffy, 1952) and Norbert Wiener his systems theory and Cybernetics (Wiener, 1948) as a methodology for complex phenomena research, theory and cybernetics play an important role in different fields of scientific research. We encounter the methods and tool of system dynamics and system thinking, which became common management tools in 1990s (Senge, 1994). Since systems dynamic models are essentially simple, one must find a compromise between simplicity, limited usefulness and complexity. One will pay attention to the methodology for parameter model values determination and the so-called mental model, which is the basis of causal connections among model variables. Thus, one will restore a connection between qualitative and quantitative models (Rosenhead, 1989). Qualitative research provides a crucial perspective that helps scholars to understand phenomena in a different way from a positivist perspective alone. (Riley and Love, 2000)

2 Systems, Systems Dynamics and Tourism

In general, it can be said that a system is a composition of interrelated components, connected in order to facilitate information, matter and energy flows. The central concept system embodies the idea of a set of connected elements, which form a whole rather than the properties of its components parts. (Checkland, 2000)

In operations research and organizational development, organizations are viewed as human systems comprised of interacting components such as sub-systems, processes and organizational structures. Organizational development theorist Peter Senge developed the notion of organizations as systems and system thinking, where the system thinking has been identified as an important leadership competency where an individual thinks globally when acting locally. (Senge, 1994)

System dynamics is concerned with the behaviour of a system over time. A critical step in examining a system or issue is to identify its key *patterns of behaviour* - what we often refer to as "time paths". System dynamics provides the basic building blocks necessary to construct models that teach us how and why complex real-world systems behave the way they do over time. A tourism system is a system concerning the tourism domain (travel, tourists, resorts, hotels, restaurants, etc.) It is a type of inter-organisational system with global and local properties. Furthermore, it is a complex system with certain structural end behavioural properties. It can be described by various components where different processes take place (economical, psychological, sociological, physical, etc). Thus, we get a link between a system and its dynamics. System dynamics, therefore, can be introduced to combine both 'hard' quantitative dimensions and the 'soft' qualitative dimensions. Forrester (1961) defined system dynamics as the investigation of the information-feedback characteristics of systems and the use of models for the design of improved organizational form and guiding policy. Coyle (1979) defined it as a method of analyzing problems in which time is an important factor, and which involves the study of how the system can be defended against, or made to benefit from, the shocks which fall upon it from the outside world.

Additionally, Wolstenholme (1990) defined it as a rigorous method for qualitative description, exploration and analysis of complex systems in terms of their processes, information, organizational boundaries and strategies; which facilitates quantitative simulation modelling and analysis for the design of system structure and behaviour.

According to Sterman (Sterman, 2000), system dynamics is a method of enhancing learning in complex systems. It is a method for developing management simulators, often computer simulation models, to help us learn about dynamic complexity, understand the sources of policy resistance, and design more effective policies.

3 Subject - Object - Model

Model building in tourism seeks to understand a complex relationship and to aid the management of a place or process. For example, in econometric forecasting of tourism flows, the purpose is to help estimate future numbers of tourists so as to permit informed decisions. (Jafari in Ryan, 2000).

The selection, upon which we choose model, depends on a system we examine and the aims of our examinations. Every development strategy, as well as tourism, needs to be presented as a whole, with all its strengths, weaknesses, and future anticipation and with use of different methods. The methodology of system dynamics (Forrester, 1961) is quite appropriate for developing a model of tourism strategy if we consider tourism as an important economic sector of the 21st century. (Jere Lazanski, 2001)

Modelling represents the activity of describing our experiences by using one of the existing languages in the framework of a certain theory. In this way, our experiences also become accessible to others: they may be proven, confirmed, rejected, broadened or generalized. This paradigm can be stated (Kljajić, 1998a) with a triplet (O,S,M). O Represents the real object, original, independent from the observer, while S represents the researcher (subject) or an observer with his knowledge, and M the model of the object. (Kljajić, Jere Lazanski, 2001) and is very similar to Peirce's triad philosophy (Peirce, 1931). The origin of things, considered not as leading to anything, but in itself, contains the idea of First, the end of things that of Second, the process mediating between them that of Third. (Peirce in Wiener, 1958) A researcher, as an observer of a complex problem, turns away from the emotional world and accepts virtual worlds of models, which brings him near to reality in its optimal form to serve the needs of contemporary and future science.

A description of a system depends on an exactly defined goal and the researcher's point of view. From a methodological point of view, which is more important, we can only understand complex systems as a whole, which means in their complete portrait in their surroundings. The external world exists independently from the observer, which isn't directly observable and for its representation, we set up simplified models. The relation between the observer S and the object O - is of essential significance in the cognitive method. The observer is a person, with all his cognitive qualities, while the object of research is the manifested world, which exists by itself, regardless of how it can be described. In this case, the object and the system have the same meaning.

The third article of the triplet M is the consecutive one and represents a model or a picture of the analysed system O. The $O \leftrightarrow S$ relation in Figure 1 indicates the reflection of human experiences to concrete reality. This cognitive consciousness represents our mental model. The relationship $M \leftrightarrow S$ represents the problem of present knowledge, respectively the translation of the mental model into the actual model. The $O \leftrightarrow M$ relation represents the phase of model validation or proof of correspondence between theory and practice, which render possible the generalization of experiences into rules and laws. The $S \rightarrow O \rightarrow M$ relationship is nothing other than an active relation of the subject in the phase of the object's cognition.

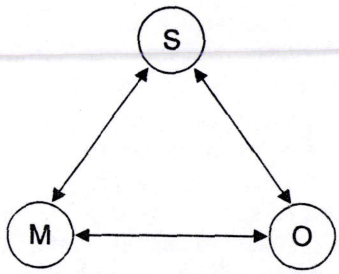

Figure 1: Subject in a modelling process

The $M \rightarrow O \rightarrow S$ relation is simply the process of learning and generalization. As we can talk about complexity of object O, we can also talk about state, goals and estimations S, about homomorphous and isomorphous connections between a model and the original. The relativity of knowledge, theory and scientific models is obvious. These develop constantly through time in elegant interaction with civilization. The connections between the principle process of modelling and the communication model among participants of complex systems are presented in the work of (Kljajić, Jere Lazanski, 2001).

4 A Concept of a Decision Making Model in Tourism

Organizational systems, among which we can place the tourism system, are dynamic. Regulation is necessary but far away from being sufficient. The most important is strategic vision of a development and system environment influence prediction. For this reason, organizational systems can be defined slightly differently, in the way that inner causes of system behaviour are emphasized. Usually they are called management subsystems. A general model of a goal-oriented system is defined with a pair (P, D) and presented in Figure 2. P presents managing process in tourism, D presents managing subsystem. Loop represents feedback information, which functions on the cause-consequent principle; therefore, we can call it reactive control. For small disturbances such control is satisfactory.

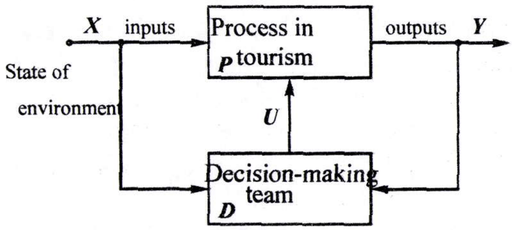

Figure 2: General model of tourism oriented system

For decision-making in organisational system, information from the environment is necessary. The chain provides feed-forward information, which represents the anticipation of the future state of the environment. It is an important part of the strategy of goal oriented systems. A person is a part of a managing system and the one who creates goals and has responsibility for the system's development. From his knowledge and conscious dependence on inter-relationships, he works towards the organization of the technical and natural parts of subsystem for achieving quality goals and functioning. There is no absolute solution; since systems are open, new goals are researched. One of best ways of possible development of visions in tourism control is the simulation method. The main paradigm of problem solving via simulation is shown on Figure 3.

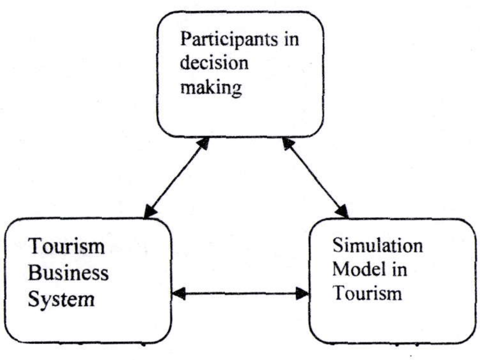

Figure 3: Simulation methodology determination with participants' involvement

Achieved experiences and future anticipation enable the development and growth of these systems. Figure 3 represents relations among participants (decision-makers), the business system and its simulation model. The simulation approach seems to be one of the better methodologies used to achieve and anticipate information for decision-making in enterprise system. Roughly speaking, it means the concepts of state, goal, criteria alternative and a state of nature, which are connected in a dynamic model interacting with decision-making groups. The business process was designed on the concept of the state-variable approach. It signifies a quantity, which represents the main entity relevant for decision-making on the top and operative level. The system for decision assessment has been organized in two hierarchical levels. The model at the top is used for the assessment of enterprise strategy. At the bottom level, the model is used for discrete event simulation, necessary for operational planning and testing of service performance.

The concept of state is convenient for achieving harmony among different levels throughout the whole system. In a practical sense, this means that when the discrete-event process is considered, variables are considered as entities as the level and rate in the system dynamics when the process is considered continuous. A conceptual view of the proposed approach is shown in Figure 4, which shows the interaction between the business system and the people involved in it - the participants in a decision making process and simulation model.

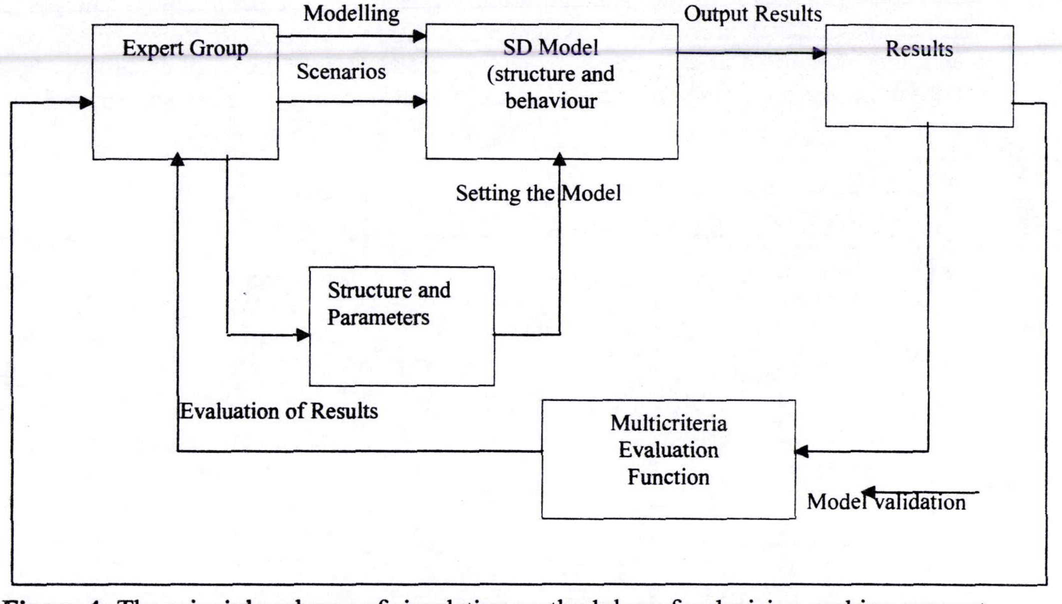

Figure 4: The principle scheme of simulation methodology for decision-making support

Following the above-illustrated approach, a group decision-making tool should be used. Work with this tool is anonymous, which enables a greater flow of ideas and reduces unwanted influences. The participants become more relaxed since no one knows where the ideas come from and thus creativity is released; this simply would not be a case in the more classical ways of working. Work time decreases and the efficiency of participants' increases. The final result is better as the decision becomes a group decision with which conflict between polarized groups is minimized and a consensus is achieved for the development of further actions. Present opportunities and future needs for this kind of decision-making system must be mentioned.

An important role can be given to expert systems and virtual wizards. A decision-making support system must satisfy both tourism service users and tourism service providers: *a)* tourism industry decision-making for rational and excellently provided service together with the participation of holidaymakers and *b)* enabling a system for global decision-making and different working areas (for holidaymakers). Therefore, we can include tourism organizations into inter-organizational system with local and global elements.

5 Developing qualitative models

Tourism is a part of development policy and it must be discussed as a whole – together with economics, infrastructure and education. System dynamic methodology enables use of all points of development view. System researchers will find tourism as a "black box", which means tourism as a system with its inputs and outputs, interactions among single subsystems. Basic qualitative strategic goals of one tourism region are shown on Figure 5:

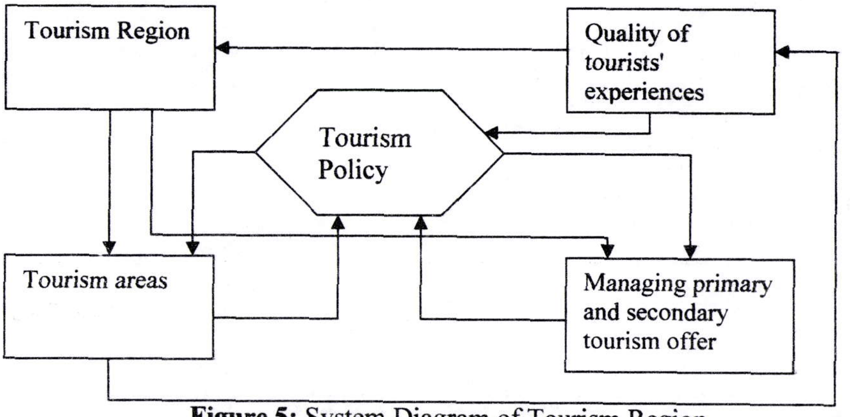

Figure 5: System Diagram of Tourism Region

For an explanation of the above-described methodology, we will present a simulation model in tourism in fig. 6. Many equivalent illustrations of systems exist, which are appropriate for computer simulation. In business management simulation, a methodology of system dynamics has been brought forward, which was suggested by J. Forrester (Forrester, 1961). All discussions considering modelling lead to the same conclusions. There are few minor differences among graphic illustrations of elements and interactions among them. Forrester suggests that the SD method has some semantic advantages for its users, who have less experience with formal methods. In practice, some authors use a causal loop diagram or an influential diagram (Eden, 1994). The methods are equivalent, the only difference lies in a fact, that an influential diagram is closer to graphs with respect to qualitative models.

Following a definition of system equations (1) one can define basic elements of a system:
Ei = *environment, attractiveness of the environment, number of tourists, investments, infrastructure, crowding, and their interconnections*
R = environment, *attractiveness of the environment, number of tourists,* which creates a simplified model

Understanding of a process is a base of *R* set connection. It can be described as follows: preserved environment (+) influences in the same direction on tourism area attractiveness (+), which influences upon the number of tourists, (+), the number of tourists influences the growth of investments into infrastructure and culture of life quality (+). On the other hand, it can be said: more tourists (+) causes environmental damage (-), which is a reason for a fall of tourism area attractiveness. At the same time, crowding (+) causes detours, traffic jam, driver irritation, accidents, anger and regrets for making a decision and having vacation in this kind of area (-).

From these qualitative descriptions, one can see what must be taken into concern. If we connect set of elements Ei on a base of their descriptions with a pointed arrow to the same direction and sign this with a symbol (+), opposite with a symbol (-), we get an influential diagram respectively qualitative model of our simplified system, shown on fig.6. From a model, one can derive that there is one basic circle (-) of causal loop, which means growth of number of tourists and borders of growth, caused by infrastructure and environment damaging. In a vision of tourism strategic development one must predict development as a whole in order to avoid limitations. If in the reinforcement circle, which consists from investments, environment preservation, only one element start to fall (-), this means fall of all other elements. (Number of tourists' decreases)

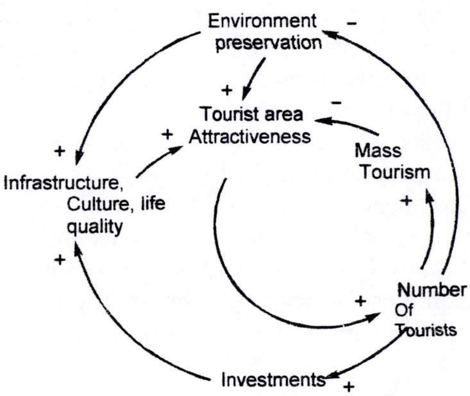

Figure 6: CLD (causal loop diagram) dependency of environment attraction, number of tourists and infrastructure investments

System dynamics is particularly useful in understanding the links between the qualitative and the quantitative aspects of tourism management. System dynamics modelling employs a set of techniques that allows both quantitative and a realistic representation of variables that are typically perceived to be qualitative. For this reason we will better model a tourism development model from fig. 6 with a consideration of other parts of sustainable development of national economy and global surroundings.

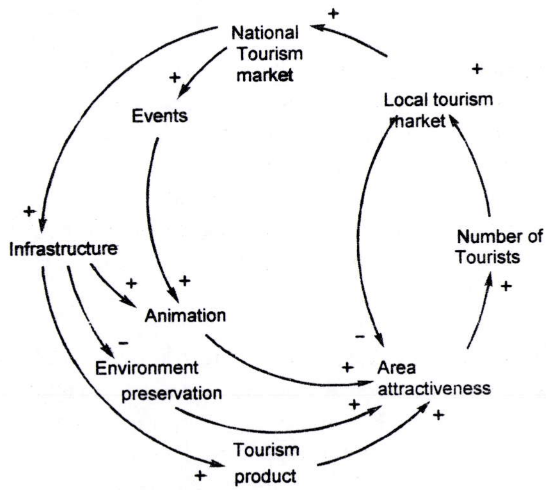

Figure 7: CLD of integral tourism development policy from a national tourism market perspective

A new causal loop diagram is shown on Figure 7. It shows a tourism market, which has a positive influence on tourism infrastructure as a secondary tourist offer (+), good infrastructure positively influences the tourist product (+), the tourist product influences attractions offered by tourism (+). The national tourism market has positive influence (+) upon tourism programs, which positively influence animation, animation later has positive influence as well (+) on, attractions, offered from a side of national tourism. Attractions cause growth in the number of tourists (+) on a local level (+), the number of tourist influences at that attraction decreases quality (-). Tourism infrastructure negatively influences environment preservation, (-), which causes fall of tourism area attractiveness. (-). A positive causal loop circles mean development, yet it must be said that every aggravation is followed by a fall in growth. For example, if the environment is ecologically poor, this influences negatively on area attractiveness, further on it follows a chain reaction on decreasing number of tourists, tourism investment reduction and a financial decline.

6 Quantitative model in the frame of Forrester's SD

Causal loop diagrams, which have been described, represent qualitative models of national tourism. They are followed by system dynamic models, which are actually simulation models. The difference between causal loop diagrams and system dynamic models is in the quantity of parameters ad concrete data needed for simulation, which are gathered in SD. A project of creating a strategy of a development is growing, when different scenarios were discussed.

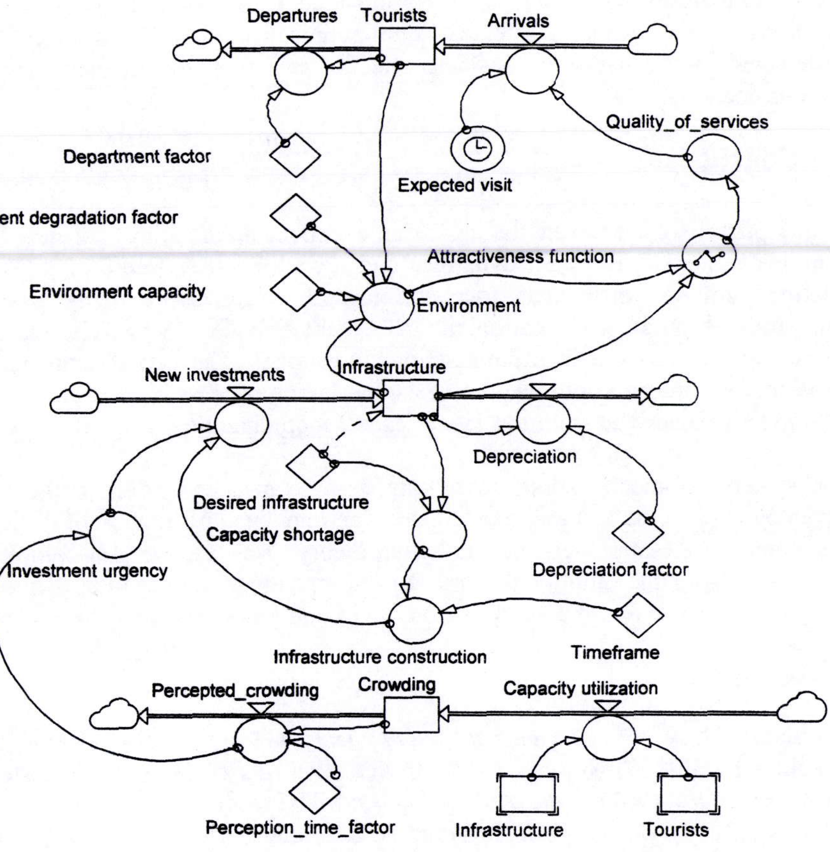

Figure 8: SD diagram of a tourism simulation model for decision making support

Figure 8 shows a system dynamics model depicting the interaction among dependence on environment attractiveness, number of tourists and investments in infrastructure. In the experiment, this model is defined to be the "real world system." Next, an exact copy of the "real world system" is made. The "model" is perfect in the sense that its non-linear stock-flow-feedback structure, its parameters, its distribution of random variates, and its initial values, are identical to those of the "real world system." The "model" is thus more perfectly specified than any actual social system model could ever be in the actual world. Stocks or Levels show a variable type and a model object in Powersim models, used to represent the state variables of a system. Levels accumulate connected flows. Array Stock has one dimension with different elements and flows in a Powersim model represent the transport of quantities to, from, and between levels, whereas connectors are links to establish an influence from one variable to another.

Using simulations, companies can test tactical decisions and experiment with marketing or product-development strategies. The purpose of simulations is to help people understanding the basics of business and, in particular, the financial implications of various decisions.

7 Conclusion

In this paper, we discussed the use of an excellent methodology to view tourism as a complex system – a system dynamics and modelling in a frame of it. We presented relations among participants (decision-makers), business (tourism) system and its simulation through a simulation model. Qualitative data, which is important in the decision-making, were incorporated into the model. The causal loop diagrams were developed in order to optimise the decision-making process in tourism and, finally, the SD model was derived from the data of causal loop diagrams.

The system approach and its modelling deserve more attention in the future. Their advantage lies in the fact that they are an experimental confirmation of those hypotheses that compose the approach and modelling theory. The observers of complex problems turn away from the emotional world and accept the virtual worlds of models, which bring them near to reality to serve the needs of contemporary and future science.

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