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Application of dynamic system in environmental impact assessment method-Case study: The man-made lake in Tehran

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Abstract. An important approach was generated to determine, predict and interpret the effects of environmental factors on a project of environment, public health & ecosystems known as EIA the most important goal of EIA is introducing and systematic survey in the case of environmental problems in different processes of decision making as well as its special activities. Through this, the analysis of development effects on environmental components was emerged. the goal of this research, is achieving mathematical pattern to evaluate environment on the basis of essential dynamism. Considering the essence of dynamic model (the existence of time dynamism), the components of the models and their relationship with were determined by the usage of professional points of view. Wherever the enough information on components and their relationship was not variable or the subject was unclear, the group decision making methods are used on the basis of intelligentsia ideas as well as using phase logic. In this way, it is possible for intelligentsia to come up with the ideas in the models so that the relationship of environmental dynamic model elements is determined in the form of functions & then, the evaluation of constructing man made lake will be provided. In this case, it is necessary to identify the phase of construction and utilization of the lake as well as the effecting or effective items. By providing questionnaires, the interviewees were asked to consider three important factors such as effect intensity, delay and the effects of interaction components in the phase of construction and utilization of the lake. As a result, it is possible to determine the desired phase by using phase log. And so, through evaluating the final results of intelligentsia points of view, the phase amount of total theoretical value was determined. In this calculation, all the effecting and affective factors in the phase of construction & utilization of the lake were considered.

Key words: dynamic system, dynamic variables, environmental component, environmental impact assessment

1. Introduction

Focusing on the origin of the methods used to study the complicated economic, engineering, management and social problems, it can be clearly shown that each method is looking for a special outlook to the problems (Wiseman, 2006), (Roudgarmi et al., 2008). Among these methods, Environment Impact Assessment (EIA) plays an important role in the process of planning, decision-making and project implementation (Khordagui, 2002). Considering the sustainable development, EIA is essentially considered as a planning tool of a project. People ask for comparing different alternatives for every kind of project and plan (Höpner et al., 2002). Each alternative involves economical cost (Abdel-Jawad et al., 1999) and benefits. Meanwhile, the correct perception of the nature of proposal and use of the similar results of project are of great importance. Some different methods used for determining key impacts, including checklists, matrices; overlaying maps and networks are among the group decision-making based on the stable variables and application (just based on the expert's opinion). The main objective of this study is achieving the dynamic model for the environment assessment based on dynamic variables. The simulation model can be used as a tool for determining and predicting the impacts on the basis of the dynamic system (Roudgarmi et al., 2008), (Kennish, 1997). The structure of the cause and effect of variables and complicated issues focusing on feedback process are solely considered throughout this model. Since, the model is based on the relationships between the elements and dynamism, determining the relationship among the dynamic model elements is of

great importance. Also, these systems proceed to the inspection of the complex problem considering the feedback process. The logical base is that the feedback structure is sensitive to the changes occurred during the time. To achieve a dynamic model, some measures have been taken. Among these substantial measures are identifying the existing dynamism amongst the components of an environmental system, predicting environmental system behavior, providing the possibility to make decisions, identifying various scenarios (proposed solutions in a simulated environment) and using experts' opinions in fuzzy situations. In the above field, there have been few sources and practically, it is only possible to study the available sources in separate fields (Haugwitz, 2005), (Skoglund et al., 2007), (Tiller, 2001)

In fact, there is no unity possibility and relationship of much information and pure data of these methods – lack of certainty in these methods doesn't mean that it is not possible to predict the future events and get to the result (Buckley, 2000). The assessment methods don't care about the comparative impacts and relationships among components (cause and effect). Also, time limitation is ignored. Comparing the methods and identification of the shortcomings, the goal is to cover the shortcomings by presenting the relative modern method for system dynamics and the environment assessment, because dynamic systems can identify the dynamism of the effective components of the environment assessment. Also, they are able to show multifunctional structures and model the feedback and time delays.

2. Materials and methods

Application of dynamic systems in EIA

Dynamic models have the ability to use structural and behavioral methods to solve complex problems at the same time (Cornforth, 1999). The components are used as the elements and sub-systems of the model during modeling process. Dynamic simulation model is a strong tool for predicting the connected behaviors of different systems in answering the stimulus signals in a period of time. Using dynamic model, identified elements and their relationship would be clear (Dale et al., 2001). Considered model provides the possibility to run many tests on the system, while different assumptions and different policies will be accomplished and their behavior will be inspected.

Following objectives will be achieved in EIA using a dynamic system:

- Possibility of the environment assessment of the proposal project in dynamic time
- Identifying the dynamism among the available components in an environment system
- Possibility of the predicting and decision-making in an environmental system according to the different views by dynamic model

Dynamic model tends to inspect the complex problems focusing on the feedback process. Therefore, feedback structures are sensitive to the changes happened during the time (Kurtz et al., 2001).

As a result, dynamic behavior is due to system’s structure. Different stages of defining dynamic modeling process are as below:

- Describing and identifying the problem, conceptualization, formulation, simulation and assessment of the model, documentation, policy analysis and finally application of the model.
- Identifying the model depends on definition of the problem and its elements. This stage, actually, is the spiritual verbal description of the symbols of problem. This process should be presented dynamically and according to the variables.
- Conceptualization, in fact, is the abstraction of the world phenomenal meanings for the model which is fulfilled in the framework of the variables. In presenting the identified model’s goals, policy, political viewpoints in modeling, consideration of the simulation model, type determining, operation degree and accomplishment are among the most important components. The goals scope and desirable accomplishment can be considered as a tool for testing the former policies. The system territory guarantees system structure parts which are necessary to produce system behavior. The system border should be vast enough to include cause – effect relationships and information. This phenomenon is very important for the system behavior. The system territory should include political powers (factors related to the policy test) and available variables (such as costs). Therefore, policies of the real system can be assessed.

The presentation process should begin and finish by the system perception. Fig. 1 shows 7 levels of modeling and their direction paths.

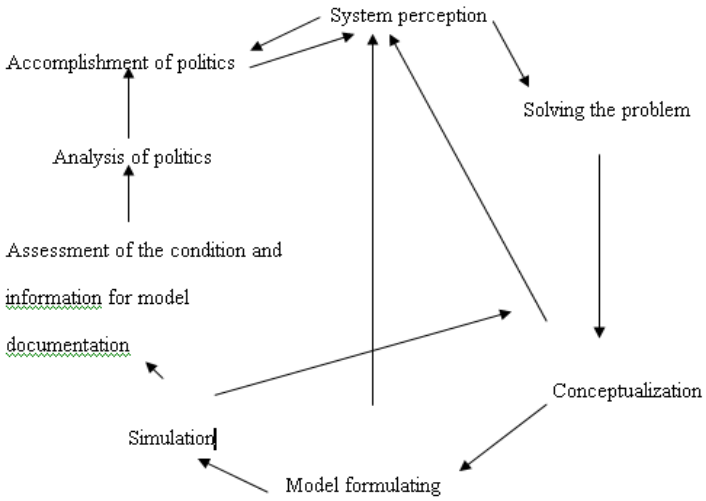

Fig. 1: Dynamic modeling levels

3. Results and discussion

Indicating the impacts using a mathematical model

In this model, there is one relation between both components shown as a transformation function. This function indicates the mutual impacts of the components. Transformation function, in fact, is an index that shows the extent of mutual impact between two components. For example, to identify the impact of component I on component j, it is required to consider both components I and J. The type of impact of I on j is a function of the following three elements: The extent of affection on other components, the duration of the effect (time constant) and the time delay. To analyze a system three elements must be taking into consideration:

1) Delay in system answer: Time required for the system to respond to an input signal.

To establish a barrier or a lake, cutting is an effecting factor for the atmosphere. Time delay means that how long does it take to effect on the atmosphere quality after cutting? Does it effect without delay after operation start or does it take a definite time to show effect?

2) The extent of responding to system: The reaction of the system to the input signal. This can act as a reinforcement, reduction or neutral element. .

Utilization of barrier or a lake can be considered as an effecting environmental parameter. Effecting factor in profiting phase is the lake watering and the tourism can be included in influenced factors. The effecting frequency means the intensive impact on the tourism rate.

3) The duration of effect: Required time for the input signal impact to be started in the system and make development? When the time elapses, the developments resulting from the signal actions die down .

Exploitation of a barrier or lake can affect environmental parameters, while among these parameters, watering and hydrology are considered as effecting factor and influenced factor, respectively. The effecting frequency means that lake watering effects just the river hydrology in a period of time or lake watering is not based on period of time, but continues in a long time. In fact, if there is transformation function such as G (S) to explain the relation between components I and j, function G (S) shall be a function of the above-mentioned indices. Therefore, transformation function between both components has turned into a Laplace general form in standard function format of first and second degree. They appear as relation 1 and 2, respectively (Fig2).

$$G(s) = \frac{k}{\tau\delta + 1} \qquad \text{relation 1}$$

$$G(s) = \frac{y(s)}{u(s)} \qquad \text{relation 2}$$

Where, K = Extent of affecting, T = Duration / time of effect (time is constant in normal situation)
N = affecting vibration frequency (in vibration), S = Laplace variable.

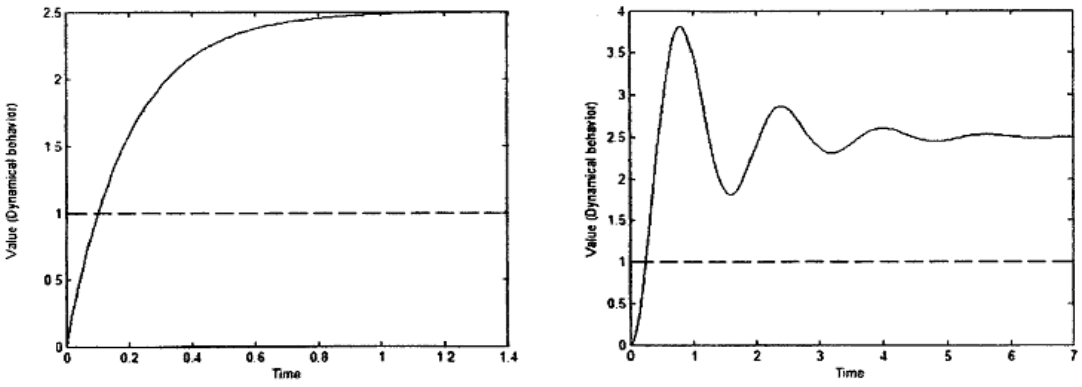

Fig. 2: Output of transformation function in first degree and second degree condition vibration

Where the impact of component I on component j is not oscillating, b = V0, then a shows the duration of effect (T). For the other values except V0, a shows the vibration death factor (ζ). In fact, the model is capable of determining the relations between the components. This model has tested the solutions required to realize the necessary goals as simulations and finally proposes the suitable solution. To identify the components, such methods as Delphi method, nominal group technique, analysis methods and other valid methods are required to be applied. For instant, during the construction of man-made lake in western Tehran (Chitgar lake), related activities lead to destructive environmental consequences. Among the resulted consequences, excavation can damage soil and flora. Such impact does not have chronologically frequency and is not vibrating/oscillating. After all calculations are done, the system should be simulated based on the internal components of the system and their relations. The components can be divided into three categories: 1- Input components which include controllable variables; 2- Output variables which show the goal of the system and are considered as decision; 3- Medium components which have interaction with input and output components and play a role in implementing the simulated model.

After modeling of system, the different strategies should be tested and deciding-making should be done based on simulation model results. For this purpose, following stages should be carried out sequentially. At first, the conceptual model and the construction and exploitation phase's activities should be identified and then implemented as this model show exclusive cause–effect relationships among the selected important elements of the system.

Modeling (simulating) of environmental impacts assessment (For a man-made lake project)

the steps of environment impact assessment of man-made lake are shown by the dynamic model. At first, the proposal project (man-made lake construction) operation and construction phase's activities are identified, then they would explain existing environment condition. To show the comparative impacts among the components, the functions among the components would be identified by the mathematical modeling – finally, after description of the problem and system comprehension, model formulating and behavior analysis, assessment, designing and policy analysis would be accomplished. For example, for the assessment of the man-made lake construction impact by a dynamic model, at first, the related activities to the construction phase such as cut and fill, purifying the operation environment, road establishment and development should be identified. Then, the influenced environment components, including physico-chemical, economical and social environment would be determined. Also, to determine the relationships among the components, expert's opinion should be used and it helps to identify the relationships in the modeling among the components. For example, cut and fill can affect quality of water. After that, the transfer function of these

impacts would be recognized in the environment impact assessment. The identified components would be categorized in 3 groups. The first group is the controllable variables for decision-making which are among the input components. The second one is the uncontrollable variables. The third one is the output components, which indicate the system goal. There are same controllable variables such as road construction and cutting in the related activities to the construction of man-made lake. Also, there are some uncontrollable components in the environment such as district and the environment plants. At last, after finalizing the system modeling, different strategies should be tested in the model. In the impacts assessment process of the mentioned project, different decisions are considered: lake construction and non-construction strategies which can be tested in the model and be decided based on the simulation results. At last, related different forms of the selected guideline in the model would be accomplished and results are shown by some curves.

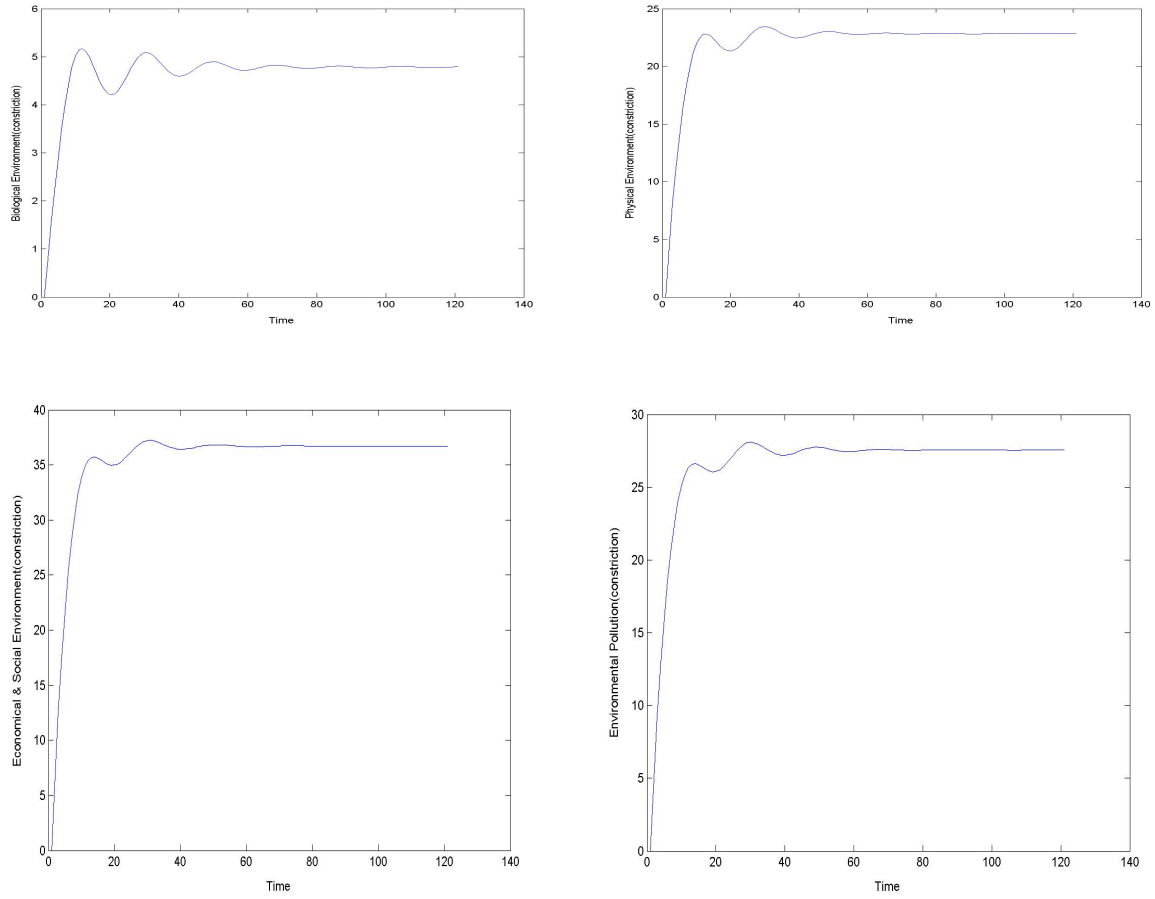

Fig. 3. Results of the model

4. Conclusion

Based on the recognition of the most important methods or the environment assessment and the inspection of advantages and disadvantages, also comparing these methods with modern tools like dynamic model for environment assessment impact, it can be concluded that using dynamic model for the environment assessment impact will be made possible Also, it will be possible to identify the dynamism among the components in an environmental system and predict the component behavior. Using the dynamic model, the suggested guidelines related to the environment impact assessment can be implemented in a simulated environment and finally the best strategy and decision will be selected, It is evident that using this method, it is possible to attain a model that behaves based on the real world and inspect the different decisions and politics in the dynamic behavior of each system. In this research, a model for the environment impact assessment based on the dynamic behavior among the internal and external components with the problem solving approach is presented in which the relationships among the model components shall be determined using the experts' opinions. In fact, the presented model is able to recognize the relationships

among components. It also is able to show variables behavior during each component changes. It also shows the influence on the components during the time and changes. Therefore, it can provide a criterion for the environmental experts to identify the best impact in the environment and be much more successful in the environment assessment.

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