İşletme Araştırmaları Dergisi
ISSN: 1309 - 0712

Journal Of
Business Research
Turk
www.isarder.org

A Suggestion For Water Resources Management: System Dynamics

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Extensive Summary

The planning of water resources management is important in order to leave healthy and sufficient water for future generations. The purpose of this study is to explain the system dynamics as a method that can be used to design an effective policy in water resources management.

System dynamics deals with how things change over time. Almost all are interested in how the past formed the present moment and how today's actions determine the future (Forrester, 1995: 16).

The concept of dynamics indicates change over time. If something is dynamic, it changes constantly. Therefore, a dynamic system is a system in which there are interactions that promote change over time. System dynamics approach is a method used to understand how the system changes over time. The elements and variables that constitute a system that changes in time are expressed as the system behavior. The aim is to understand the basic behavior system of the variables, to discover the factors that cause this mode of behavior and to improve the system behavior. Thus, it could be argued that system dynamics is a method to explain how the systems change with time. In dynamic systems, variables influence each other simultaneously (Barlas, 2005a; Ayanoğlu and Gökçe, 2007).

Dynamic complexity arises from connections and disconnections that link social and business systems. When a change occurs in one part of the system, it causes change in another part later (sooner or later). These effects could not always be observed clearly, usually they are beyond expectations (Morecroft, 2015: 21).

Dynamic complexity arises due to the following systems characteristics (Sterman, 2000):

Dynamics: Systems constantly change. Even an apparent constant would change over a long time period.

Close Relationship: The components of the system have a strong interaction.

Management by feedback: Actions return back to themselves. Decisions cause a change and trigger other system components to take action.

Nonlinearity: Systems are mostly nonlinear, i.e. the effects are not proportional to their outcomes in general.

Historical dependence: Many actions have no return. An action taken will cause irreversible effects as a result of several feedbacks.

Self-organization: The dynamics of a system arises from its own internal structure.

Adaptability: Rules and abilities change over time. They allow selection and multiplication as they develop over time.

Contradiction to intuition: Causes and effects are different from each other in the temporal and spatial contexts. Individuals search for the reasons of events in the periphery of the events they are trying to explain.

Resistance to Politics: The complexity of the system that we work on could reduce our ability to understand the system. After all, many obvious solutions fail and even worsen the situation.

Determination of Reconciliation: Time delay feedbacks provide different responses in the short and long term. Often a good response occurs before the bad behavior (response).

System dynamics is designed to model, analyze and improve socio-economic and administrative systems using a feedback perspective. Dynamic structured administrative problems are modeled by mathematical equations and using computer software. Dynamic constructions of model variables are obtained using computer simulations (Forrester 1962; Ford 1999; Sterman 2000; Barlas 2008).

The main principle of system dynamics is that the ongoing accumulation of the complex behavior of organizational and social systems (human, material, financial assets, information, biological and psychological states) is also the result of balancing and empowering feedback mechanisms. (Richardson, 1999).

System dynamics is an interdisciplinary problem-solving methodology that utilizes several significant thinking skills such as dynamic thinking and cause-and-effect thinking. System dynamics is a disciplined collaborative approach that could accelerate learning by combining a multifaceted perspective that provides insight into complex and interactive issues (Richmond 2010, Soderquist and Overakker 2010; Ferencik, 2014).

System dynamics is a method that allows analysts to separate complex social, and behavioral systems into components, to visualize them by reconstructing them as a whole again, and to develop a simulation model (Tang and Vijay, 2001: 3).

There is never one single correct answer in system dynamics. Since system dynamics represents the relationships within the current system, it presents multiple possible approaches that could be applied, instead of providing a single correct answer. Each approach could provide some of the desired result, as well as some unexpected ones. In fact, another significant characteristic of system thinking is to become aware why we preferred a solution over others (Sterman, 2000: 127-133). System dynamics was designed to help managers make decisions similar to other information technologies. The aim of system dynamics studies is to assist decisions by analyzing old policies and designing new ones (Wheeler, 1994: 80).

System dynamics models are not derived statistically from time series data. They are statements related to policies and system structure that guide decisions. Models include admissions made about the system. A model is only as good as the expertise that underlies its formulation. A good computer model is distinguished from a bad one by the accuracy of its reflection of the system it represents. Several other mathematical models are limited due to the nonlinear nature of the real system and the lack of their inclusion of several feedback cycles. On the other hand, system dynamics computer models could reflect real system behavior (Forrester, 1995: 6).

System dynamics is based on information feedback theory and provides symbols for system management. These symbols include diagrams, equations, and programming languages for computer simulation (Morecoft and Sterman, 1994: 15).

The objective of system dynamics is not optimization, but to examine the system behavior in the long run at macro level against specific changes and to help determine the strategies. System dynamics aims to achieve a holistic view of the system and to determine how interactions influence the system as a whole. It is often used for large organizations and global events. However, it could also be used for micro-level and small organizations (taking into account their intermittent structure in flows and levels). The most significant function of system dynamics is to improve system behavior by explaining the structure and behavior of the system. The system dynamics has a broad approach to problems to facilitate monitoring, development, and reorganization of the system performance. As a result, the improvement of the performance of one part of the system prevents the deterioration of another part of the system (Hesan et al., 2014; Başkaya, 1997: 93; Özbayrak vd., 2007; Towil, 1996). In system dynamics, generally a "what if" analysis is conducted.

System dynamics is a compilation of tools by which we could understand the structure and dynamics of complex systems. What was meant by complexity is the fact that these systems contain characteristics such as delay, feedback, and a large number of stocks. System dynamics is based on the control theory and modern nonlinear dynamics theory. However, understanding the complex systems requires more than solely mathematical tools. Since complex systems involve human and social systems as well as physical and technical tools, system dynamics is in direct relationship with cognitive and social psychology, economics and other social sciences. Therefore, it could be argued that system dynamics is an interdisciplinary method (Öğüt and Şahit, 2012: 5, Senge, 2002, Sterman, 2000).