Available online at www.sciencedirect.com
SCIENCE DIRECT
FUTURES
Futures 38 (2006) 74–92
www.elsevier.com/locate/futures

Navigating towards sustainable development: A system dynamics approach

Peder Hjorth[a,1], Ali Bagheri[a,b,*]

[a]Department of Water Resources Engineering, LTH, Lund University, P.O. Box 118, S-221 00 Lund, Sweden
[b]Civil Engineering Department, Sharif University of Technology, P.O. Box 11365-9313, Tehran, Iran

Available online 10 August 2005

Abstract

Traditional fragmented and mechanistic science is unable to cope with issues about sustainability, as these are often related to complex, self-organizing systems. In the paper, sustainable development is seen as an unending process defined neither by fixed goals nor by specific means of achieving them. It is argued that, in order to understand the sources of and the solutions to modern problems, linear and mechanistic thinking must give way to non-linear and organic thinking, more commonly referred to as systems thinking. System Dynamics, which operates in a whole-system fashion, is put forward as a powerful methodology to deal with issues of sustainability. Examples of successful applications are given.

Any system in which humans are involved is characterized by the following essential system properties: Bounded rationality, limited certainty, limited predictability, indeterminate causality, and evolutionary change. We need to resort to an adaptive approach, where we go through a learning process and modify our decision rules and our mental models of the real world as we go along. This will enable us to improve system performance by setting dynamic improvement goals (moving targets) for it.

Finally, it is demonstrated how causal loop diagrams can be used to find the leverage points of a system.

* Corresponding author. Address: Department of Water Resources Engineering, LTH, Lund University, P.O. Box 118, S-221 00 Lund, Sweden. Tel.: +46 46 2228134; fax: +46 46 2224435.
E-mail addresses: peder.hjorth@tvrl.lth.se (P. Hjorth), ali.bagheri@tvrl.lth.se (A. Bagheri).
[1] Tel.: +46 46 2224871; fax: +46 46 2224435.

0016-3287/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.futures.2005.04.005

1. Introduction

We have long believed that science and technology can provide effective solutions to most, if not all, environmental problems facing modern society. However, the validity of this optimistic assumption has become increasingly questioned. The scientific system, thus, faces a crisis of confidence, of legitimacy, and ultimately of power, as there is a growing feeling from many quarters that science is not responding adequately to the challenges of our times, and particularly, those posed by the quest for sustainable development. Issues about sustainability are often related to complex, self-organizing systems, and although there has been a gradual fleshing-out of the meaning of sustainable development, most researchers still find it difficult to grasp the essence of the concept. For instance, most scientists still find it hard to accept that sustainability should not be perceived as a 'project' that has an end point, but as an ongoing process that needs to be regarded as part and parcel of everyday work.

Modern science is characterized by ever-increasing specialization. As a result, it has delivered lots of knowledge but very little understanding. Basically, classical science, be it chemistry, biology, psychology, or the social sciences has focused on isolation of elements of the observed universe. The common belief has been that if we know everything about the parts, we will understand the whole. However, to create understanding, it is not enough to just study parts or processes in isolation. All this knowledge is, thus, in dire need of synthesis through some kind of multilevel and multi-dimensional graph of interconnections. There is a need to accept Leibniz's idea that within an entity of interacting parts, no part can be changed without triggering changes all over the whole. This means that we need to solve the decisive problem of how the order and organization unifying the parts affects the behavior of the whole system.

Likewise, the engineering profession has to learn that arithmetic is a complement to, not a substitute for thought. As several scholars have pointed out, the very power of the computer to simulate complex systems by very high-speed arithmetic has prevented search for those unifying and simplified formulations that are the essence of progressive understanding. The uncertainties related to complex problems will not be resolved by mere growth in our data bases or computing power.

Nonetheless, there is a need to try to bridge the gap between what is known and what is done. To this end, it is essential that research move beyond classical mono-disciplinary and even inter-disciplinary lines to one trans-disciplinary in nature, and fully integrates this approach in its problem solving efforts. There is an emerging understanding that the quality of the decision-making process is absolutely critical for the achievement of an effective product in the decision. This new understanding applies to the scientific aspect of decision-making as much as to any other.

As Meadows et al. [23] point out, the world society is still trying to comprehend the concept of sustainability, a term that remains ambiguous and widely abused even more than one and a half decade after the Brundtland Commission coined it. Therefore, the aim of the present paper is to show how sustainable development can be dealt with by using the system dynamics approach—a feature of systems thinking that considers dynamic relations in a system holistically. Section 2 discusses the concept of sustainable development and some of the efforts made to make the concept operational. Then it goes