Chapter 2
Sustainability Assessment in a Geographical Region and of the Activities Performed

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ABSTRACT

The applicability of emergy analysis (EA), a nature oriented thermodynamic analysis technique, as a regional sustainability assessment tool is explored in the context of an Indian village (Rampura). EA provides information about how much environmental support is required, system renewability, system efficiency, load of system to environment and dependency of system on external resources (self-sufficiency). The results of Rampura analysis reveal that sustainability is achieved neither at village level nor at subsystem levels. The chapter shows that the effective use of the renewable local resources can reduce the dependence on external resources and increase self-sufficiency and sustainability

INTRODUCTION

Sustainability is a complex concept since social, economic, technical and complex dynamic factors are decisive in a simultaneously interacting manner (Bakshi, Ziv, & Lepech, 2015). Hence, considering only one dimension of events does not create success in assessing a multi-dimensional phenomenon like sustainability. In today's world where many of thresholds of Earth's carrying capacity in life support mechanisms have been crossed (Steffen *et al.*, 2015), analyzing the interaction of natural and anthropogenic systems is crucial in order to cease the further deterioration and start the restoration of natural capital (Mellino *et al.*, 2015). In that regard, emergy analysis (EA) can be an effective tool to evaluate the interaction between natural and anthropogenic systems because of the insights it can provide.

EA is a nature oriented, thermodynamic analysis technique. Odum (1996) expresses emergy as "the total amount of available energy of one kind that is directly or indirectly required to make a given product

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or to support a given flow." EA quantifies total available energy (emergy) input flows to a system and classifies these flows as renewable, non-renewable and purchased. Classification of emergy input flows enables calculation of emergy metrics providing information about how much environmental support is required for the area or process in question, system renewability, system efficiency, load of system to environment and dependency of system on external resources. Detailed information about emergy analysis and its application are given in *Emergy Analysis Technique* section which follows *Background*.

The aim of this chapter is to validate the applicability of EA as a regional sustainability assessment tool and to evaluate sustainability of human activities and their interaction with nature. With this purpose, The Ohio State University research team chose Rampura Village in Jhansi district of Uttar Pradesh, India as the project site. Rampura village is chosen as the project site because of successful implementation of capacity building applications as well as availability of wide range of data which improves analysis quality. Moreover, Bundelkhand is a semiarid region suffering from lack of water and vulnerable to climate change. The area went through a 4-year-long drought, which caused greater suffering for the village residents who are already bearing some effects of climate change problems (Development Alternatives, 2011). Hence, the area needs a quick shift towards sustainability and assessment of the activities performed. Here, the research team worked in collaboration with a non-governmental organization (NGO), Development Alternatives, uniting NGO's field experience with their holistic analysis experience. Development Alternatives works in the area of sustainable development, and capacity building of rural people to improve their income generation capabilities (DevAlt, 2013). Its technology disseminating branch TARA (Technology and Action for Rural Advancement) has been working in the Bundelkhand region (region including Rampura village) of Central India for over 10 years (TARA, 2013). More detailed information about Rampura, Development Alternatives and emergy analysis study carried out can be found in *Rampura Village Case Study* section.

BACKGROUND

Prior to performing a regional sustainability assessment study, one should define what sustainability or sustainable development means. One definition for sustainable development given by World Commission on Environment and Development (WCED) in 1987 is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). This definition is vague in terms of foreseeing what the needs of future generations will be and how the current needs will be met without compromising an unknown future (Marshall & Toffel, 2005). The vagueness in this definition of sustainability is also due to lack of unanimity in defining what is regarded as sustainable. To Costanza and Patten (1995), sustainability is not a "definition", but a "prediction" problem. One can only determine a system as sustainable after seeing the results for certain. In that regard, to better objectify the sustainability concept, the "time and space scales" should be specified regarding what is considered as sustainable and unsustainable (Costanza & Patten, 1995). In nature, systems are interconnected within a hierarchical order through energy and material exchanges (Odum, 1996).

Entities which are higher in the hierarchy encompass broader time and space scales. For instance, ecosystems have longer lifetimes than the species they contain or species survive longer than an individual of the species. Hence, each entity has an expected life span increasing as the entity ascends higher in the hierarchy. Based on this fact, Costanza and Patten define a sustainable system as "one attains its full expected lifespan within the nested hierarchy of systems within which it is embedded" (Costanza & Patten,